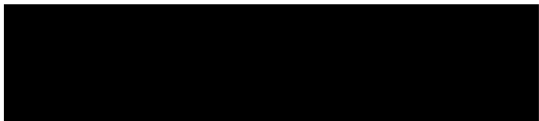


A LITERATURE SURVEY  
ON  
THE INFORMATIVE VALUE OF  
SAMPLED IMAGES

Prepared Jointly

by

STATINTL



and



STATINTL

Perkin-Elmer Corporation

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Introduction:

The primary goal of an anticipated experimental program is addressed to the question, "How should photographs be transmitted and received in a minimum of time while satisfying the search and detailed analysis needs of the user?" Prior to beginning the experimental research, it was considered wise to survey the technical literature to determine the usefulness of previous work. Thus, the methods used in searching and reporting were strongly dictated by the question stated above.

Procedure:

We searched the literature and selected approximately 200 papers which were read or scanned to establish relevancy to the question asked above. Each of the 24 papers considered most relevant was carefully reviewed, commented on, and is given with the author's summary or abstract in Appendix A. Only a few of these 24 papers are directly relevant while the others are only indirectly relevant.

The large number of papers considered not at all or marginally relevant is given in Appendix B, with the author's abstract or summary. A considerable number of papers and books generally on the topic of interest was read and studied for our own benefit; such reading provided useful background information and answers to specific technical questions generated by the performance of this literature survey.

Conclusions:

Our survey of the literature showed a surprising lack of work on the informative value of sampled images. The primary concern of most of the authors was with the implementation of image manipulation techniques, for example, bandwidth reduction schemes, image enhancement, digital processing, or image scanners and reconstruction apparatus. Little emphasis was placed on human performance as a function of image characteristics.

In the few papers where human performance was considered, either the characteristics of the photography being sampled were not properly specified, or the task performed was not one of extracting information from the imagery.

The specific conclusions of our literature survey are as follows:

1. Except for one paper (Izzo-Appendix A), no work was found on the effects of the size and shape of the scanning spot, and the overlap of the scans on the informative value of sampled images. In the single paper dealing with scanning spots, the investigator's primary concern dealt with the detailed characteristics of the laser scanner which was constructed and the measurement of the maximum attainable **resolution**.
2. Most of the investigators did not systematically evaluate the imagery by having subjects perform a task or by other sound experimental techniques. Instead, their own judgment usually was used to evaluate the goodness of the different kinds of images produced.

3. Almost all of the papers dealing with objective evaluations of imagery dealt with the aesthetic or pleasing aspects of pictures. Those few reported experiments dealing with performance or the informative value of images include those by Oatman (July and Sept. 1965 - Appendix A), Shanahan, (Appendix A), and Freeberg (Appendix A). These three investigators were concerned only with the effects on performance of differences in the horizontal bandwidth of a television type display. Unfortunately, each of these studies had serious deficiencies (Appendix A).

4. In the few papers reporting a systematic investigation of human performance rather than judgments, subjects were required to detect an object or a gap in a Landolt Ring (an acuity measure). Measures of this kind show a very low correlation with recognition or discrimination measures and therefore are not directly useful in predicting the recognition performance of subjects.

5. In all the surveyed literature discussing experimental work with sampled images, the investigators described in detail only those picture characteristics with which they were concerned; in most such instances, these characteristics are not those solely needed to properly specify the relation between system parameters and information extraction by the human.

In conclusion, then, the survey of the literature revealed little reported work which is directly useful in answering the question posed in the introduction, or in providing the basic foundation with which to plan experimental research such as that recommended in the following section. Nonetheless, some of the literature has been helpful in establishing the approximate limits of the number of grey levels of digitized pictures required

to obtain "reasonably good" image quality. Also, the literature revealed those bandwidth reduction techniques that are obviously inadequate for solving the problem at hand.

Recommendations for Future Work:

As a result of this literature survey, we recommend the performance of three basic experiments. They are:

1. To determine the informative value of sampled images as a function of the number of scans per scene object. In addition to providing data of fundamental importance, the results of this experiment will be important and useful in establishing the number of scans per scene object which will optimize the sensitivity of the performance measurements to be made in future studies.
2. To determine the informative value of sampled images as a function of the shapes of the reading and writing spots. The effect of several distinctly different spot shapes on the human performance in information extraction will be examined. Also, this experiment will demonstrate which spot shape is optimum for use in subsequent studies.
3. To determine the informative value of digitized sampled images as a function of the number of grey levels used in quantizing.

The subject's task in each of the experiments will be to identify the objects in the pictures. Each of the recommended experiments should be conducted with at least two types of objects. The purpose in using two or more object types will be to indicate whether or not the object type affects the results obtained. More details of the recommended experiments are given in a separate document.

The need for the performance of this type of research cannot be overemphasized. The comments of A. Reeves, made in 1965 with regard to telephony, are typical of other investigators when he states, "It was clear that nothing but subjective tests could provide the information needed for design; and it is strange that even now some PCM planners and committees seem to place a magical reliance on calculated quantizing noise power, before those few subjective tests now in progress have even been completed, let alone interpreted for the designer. It is strange too that these very necessary, systematic, subjective tests were not started by someone much sooner."

APPENDIX A

REFERENCES WITH COMMENTS

References include author's abstracts, when available, and our comments. The references are given in alphabetical order of (Senior) author's name. The numbers in parentheses are for our filing purposes and should be disregarded.

(24.10)

THE MEASUREMENT OF RANDOM MONOCHROME VIDEO INTERFERENCE

J.M. Barstow and H.N. Christopher; Bell Telephone Laboratories, Inc.

A.I.E.E. Trans., Part I, Jan., 1954, p. 735

SUMMARY:

The authors measured the subjective effects of random video noise composed of different frequencies. The subjects' task was to set test noises varying from 7.22 mc to 40 kc wide equal in interference to a reference noise. The reference noise was a 7.22 mc low-pass band of flat noise at about 7 db above the threshold of visibility.

The authors summarized the results as follows:

The frequency weighting derived from the judgement tests is given in Fig. 1. This weighting is for use with a simple power-summing measuring device.

The general principles derived from the tests may be summarized as follows:

1. Low-frequency noise is judged much more interfering than high-frequency noise of equal power.
2. A given amount of noise power is judged more objectionable if it is concentrated in a narrow band than if it is spread out over a wider band in the same frequency region.
3. Human vision in combination with the present television monitors does not precisely sum weighted noise powers in arriving at an over-all assessment of the interfering effect of random noise bands. However, a reasonable compromise can be obtained with weighting applied to a power meter. In the region of 7 db above threshold, average errors of the order of 1 db with maximum errors of 2 db will obtain.
4. At frequencies above 4.5 megacycles (mc) an unexpected effect was observed called sparkle effect. When the total noise power is contained in the region above 4 mc, sharp points of light of very brief duration appear on the raster. It is believed that this effect is the result of the random occurrence of high peak potentials in the random noise which produce the sharp points of light on the raster before the extremely fine-grain noise effect becomes visible. The sparkle effect tends to flatten the weighting above 4 mc.



(24.10) Continued

COMMENTS:

One of the limitations of the study conducted by these authors is that no check was made on the dependence of noise objectionability on the original picture. The authors used a uniform grey area after they found that subjects were basing their judgments of noise in the middle grey areas of the picture. Since the conduct of this study, Huang has reported that the objectionability of noise is related to the original picture. He reports "...that noises which contain frequencies similar to those of the picture are less annoying."

Another limitation of the study is that the data were derived from judgments of equality of interference. There is no way of knowing how such judgements relate to the amount of information the observer can extract from the imagery.

(24.60)

THE INAPPROPRIATENESS OF COMMERCIAL TELEVISION STANDARDS FOR MILITARY NIGHT OPERATIONS

L. M. Biberman; Institute for Defense Analysis Research and Engineering Support Division

Research Paper P-235, January 1966; AD 479585.

SUMMARY:

Report discusses problems inherent in images on a conventional 30 frame, 525 line, 2:1 interlaced raster.

- 1) 2:1 interlace system results in an accumulated relative motion smear effect for 1/30 sec. which limits the size of the resolution elements at the various flight speeds.

Since the smear is independent of TV optics or camera tubes, no improvement in these components will improve resolution.

The author concludes that the limitation in resolution lies in the specification of the 525 line frame; consequently, the commercial form of presentation--the 525 line, 30 frame/sec., 2:1 interlaced format is inadequate for military applications (navigation and target acquisition).

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COMMENTS:

There are several highly subjective, qualitative statements which require experimental confirmation.

"... motion seen by the eye on a series of crisp, sharp, moving frames permits better recognition than does a series of motion-smearred frames presented in the same manner."

"... it should not be inferred that laws governing the resolution and recognition of still imagery or stop-frame imagery apply with one-to-one correlation to motion picture presentation."

"The results obtained by integrating motion in a sensor and then presenting motion pictures to the eye for appraisal are quite different from results obtained by presenting a series of sharp images in motion picture presentation and allowing the eye to deduce the characteristics of motion."

Although the author's conclusions seem to be correct, there is no information available on:

- a) How these conclusions were obtained
- b) How they are supported by experimental evidence
- c) How to describe the subjective judgments of the author in terms of physical characteristics necessary for system design and

(24.3)

#### IMAGE QUALITY ENHANCEMENT

R.W. Brainard and G.N. Ornstein, North American Aviation Inc., Defense Documentation Center, April 1965; AD 616-895.

#### SUMMARY AND COMMENTS:

Some background information is discussed in the first part of the paper concerning the factors determining image quality: resolution, image sharpness, acutance, and image definition.

An empirical formula is derived from the experiments which expresses the relationship between definition, acutance and resolution. The authors state that further studies are required to describe the precise relationship between these factors.

The importance of edge gradients in target recognition is emphasized throughout the report. Studies cited by the authors indicate that the efficiency (speed and accuracy of performance) with which the display is searched is considerably reduced by blurring the image. Since the image blur is a reduction in the slope of image edge-gradient, the image quality enhancement should be based on the slope of these edge gradients.

There are references to the optical properties of the human eye and it is generally accepted that the apparent sharpening of boundaries corresponds to a second derivative correction of the retinal image.

Similar techniques can be used to compensate for the spread of edge-gradient introduced by the optical system. If the derivative of an image is obtained and subtracted from the original image signal, the quality (acutance, resolution, contrast) of the resulting image will improve considerably.

An experimental apparatus for electro-optical signal processing is described in the second part of the report.

An NBS resolution test chart, sine-wave test targets, and aerial photographs were used for enhancement purposes. Early results indicate that the subtraction of second derivative from the original signal produces the highest level of enhancement.

The purpose of the report was to establish the efficacy of image enhancement techniques only. Further investigation is scheduled by the authors to determine the effects of signal differentiation on human performance in information extraction generally, and target identification specifically.

(24.4)

ESTIMATION OF THE SUBJECTIVE EFFECTS OF NOISE IN LOW-RESOLUTION TELEVISION SYSTEMS

R.C. Brainard, F.W. Kammerer, and E.G. Kimme; Bell Telephone Labs.

IRE Transaction on Information Theory (IT-8) 1962, p.99.

(Author's) SUMMARY:

A model for the subjective effects of noise on TV picture quality is described. Experimental and data-processing procedures are developed from this model which yield a subjective noise sensitivity function of noise frequency for monochrome low resolution video pictures. The results obtained apply to high levels of noise power. Two noise sensitivity functions are obtained using these experimental methods--one for still pictures and one for live pictures.

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COMMENTS:

The authors extended the results of earlier works by Rüller and Demur to video systems characterized by lower resolution and higher noise levels than commercial systems.

The investigation is based on the statistical comparability and equivalence of noise effects.

The quantitative statement of the idea of equivalence is expressed by

$$\int_0^{\Omega} W(\omega)N_1(\omega)d\omega = \int_0^{\Omega} W(\omega)N_0(\omega)d\omega$$

according to the authors, where

$W(\omega)$  is the so-called noise sensitivity function and defined on the frequency range

$$0 \leq \omega \leq \Omega$$

$N(\omega)$  spatial densities of noises.

During the experiments, uncorrelated broad-band noises (several spectrally different broad-band noises and some fixed reference broad-band noises) were compared and the noise sensitivity function determined experimentally for still pictures and live test objects.

The results from the live test differ considerably from those of still test and are generally less reliable.

The authors state that: "...the evidence of uncontrolled variations in the live-picture experiment make it clear that further studies to isolate the effects of experimental procedures, quality of the video presentation, and dynamic aspects of the pictures are needed."

(24.33)

NOISE LIMITATIONS TO RESOLVING POWER IN ELECTRONICS IMAGING

J.W. Coltman and A.E. Anderson; Westinghouse Research Labs., Pittsburgh, Pa.

Proceedings of the IRE, May, 1960, p. 858

(Authors') SUMMARY:

A theoretical derivation, verified by experiment, shows that the maximum visible line number of a displayed bar pattern is directly proportional to the signal-to-white-noise ratio. The constant of proportionality and the effect of finite screen boundaries have been experimentally determined. It is found both theoretically and experimentally that the masking effect of white noise depends only on the noise power per unit bandwidth, and is independent of the upper frequency limit of the noise spectrum, provided that this exceeds the frequency limit set by the eye.

These results can be used together with the aperture response of any imaging system to predict in quantitative terms the resolution limit as a function of the signal and noise levels. As an example, the theorems postulated are used together with the measured amplitude response function of the 5820-image orthicon to obtain a universal resolution vs signal-to-noise ratio curve for beam-noise-limited tubes of the image orthicon type. The predicted performance is in good agreement with experimental results. A similar set of curves for quantum-noise-limited image tubes is also given. The effects of object contrast variation, signal integration in time, and the presence of spurious background are presented.

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COMMENTS:

The authors describe data that are useful in predicting the visual resolution limit of noise-limited imaging systems from the noise power per unit bandwidth and the sine wave response of the systems. The limits of visual resolution were obtained by having subjects detect the presence or absence of sine wave patterns of different frequencies for different signal-to-noise ratios.

The problem with data obtained in this study, or any data based upon the visibility of sine wave pattern, is that they cannot be used to predict the usefulness of a system when the output of the system is viewed by humans. Obviously, in most operational systems the human's task is not to detect sine wave patterns but to detect and identify complex images. Since the relation between the visibility of a sine wave pattern and the detection or identification of complex images is not known, resolving power measurements based on the visibility of sine wave patterns are of limited value.

(24.89)

THE 25TH ANNIVERSARY OF PULSE CODE MODULATION

E.M. Deloraine, Laboratoire Central de Telecommunications, ITT Affiliate; and  
A.H. Reeves, Standard Telecommunications Laboratories, ITT Affiliate  
IEEE Spectrum, May 1965, p. 56

SUMMARY AND COMMENTS:

These authors are among the earliest investigators of Pulse Code Modulation. In fact, Reeves obtained several of the earliest patents on pulse time modulation and pulse code modulation techniques.

Although this paper deals primarily with telephony, an interesting and very pertinent observation is made. The comments of particular interest deal with the effect of quantizing noise on the quality of telephony and need for psycho-physical experimental data for the design of systems and the lack of such data during the development and use of various systems. Part of the paper is quoted here: "It was clear that nothing but subjective tests could provide the information needed for design; and it is strange that even now some PCM planners and committees seem to place a magical reliance on calculated quantizing noise power, before those few subjective tests now in progress have even been completed, let alone interpreted for the designer. It is strange too that these very necessary, systematic, subjective tests were not started by someone much sooner".

This call for psycho-physical experiments by these prominent investigators emphasizes the need for the assessment of human performance with systems having an output specifically designed for use by humans.

(10.30)

FORM PERCEPTION IN VIDEO VIEWING: EFFECTS OF RESOLUTION DEGRADATION AND STEREO ON FORM THRESHOLDS

N. Freeberg; Department of Medical and Biological Physics, Airborne Instruments Laboratory, A Division of Cutler-Hammer, Inc.

Technical Documentary Report No. ESD-TDR-63-136, Dec., 1962; AD 401654

(Author's) SUMMARY:

Form Recognition and Discrimination Thresholds were studied as a function of 4 levels of Video Resolution Degradation and 2 Viewing Methods (Normal Binocular Viewing and Stereo Viewing). Measures of pattern acuity for a video presented target (Landolt Ring) were also obtained and correlated with the Threshold measures.

Four solid stimulus forms were randomly constructed within the constraints of equivalent size and "complexity" (number of contour turns), asymmetry, and angularity of contour. Two sets of form faces were randomly chosen from the four forms - one set for Non-Stereo and one set for Stereo presentation.

Results clearly indicated the association of threshold increases with corresponding percentage degradations in the video image. Recognition Threshold values were not significantly enhanced by the particular stereo system used, whereas Discrimination threshold values - which depended primarily upon contour discrimination - were significantly improved.

Correlations between video pattern acuity and form threshold scores were low and insignificant, generally confirming previous findings for non-video form perception. However, there are unique characteristics of the video image, such as the orientation of the pattern in relation to scan lines, which can affect visual acuity.

The randomly generated and randomly assigned form faces differed significantly from one another within each set of faces chosen. There is serious doubt that forms can be equated for visual threshold values on the basis of form complexity variables determined from previous studies or by some degree of randomization in their construction. The number of significant variables that make up the basic perceptual dimensions of a form and their interacting effects require far more clarification.

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COMMENTS:

The horizontal resolution of a 525-line TV system was reduced by either 0, 10, 20, or 40% by reducing the horizontal bandwidth. These four levels of resolution are what is referred to in the summary as "4 levels of Video Resolution Degradation."



with Landolt rings do not correlate with form recognition and form discrimination thresholds. Consequently, the data obtained are of limited use for designing line-scan systems that are used by the observer to distinguish among or to identify targets.

Two peculiarities of the report are notable. First, the dependent measure reported was called a "recognition factor," which was defined as displayed target width (width of the gap) divided by displayed width of view (total field of view on the monitor). It is surprising the author did not use the more commonly reported value of visual angle subtended by the gap. Second, no statistical tests or reliability estimates were reported for the data presented.

(24.104)

EFFECTS OF ANALOG-TO-DIGITAL CONVERSION ON HIGH-RESOLUTION PHOTOGRAPHIC INFORMATION

C.C. Gauder, P.A. Boeing; Electronic Warfare Division, Air Force Avionics Laboratory

Proceedings of the International Aerospace Electronics Conference, Dayton, Ohio, May 11-13, 1964, pp. 408-415.

SUMMARY AND COMMENTS:

A brief review is given of pulse code modulation and delta modulation as applied to the analog-to-digital conversion of photographs. Based on subjective picture quality criteria, it is concluded that 6-bit PCM is better than 2-bit delta modulation when the photograph is sampled at the Nyquist interval; and that 6-bit PCM is worse than 2-bit delta modulation when the photograph is sampled at twice the Nyquist sampling interval.

An experimental flying spot scanner setup is described with which photographs, with a resolution of 100  $\ell$ /mm. resolution using 4, 5, 6, and 7-bit PCM. From these experiments it is concluded that five-bit PCM produces images which are just acceptable, and that 6-bit PCM is satisfactory, and that little additional quality is obtained with 7-bit PCM. These conclusions are based on the subjective judgments of the authors and are not substantiated with experiments.

In describing their subjective judgments the authors refer to fine detail consisting of buildings, etc. which illustrates that their judgments were strongly influenced by the scale of the aerial photographs used in their experiments. Since the original photographs and the respective digital images are not well described in terms of physical characteristics, and since the worth of the digital images was determined by the subjective judgments of the authors, the conclusions of this work are not necessarily reliable or valid.

(24.78)

PREDICTIVE QUANTIZING OF TELEVISION SIGNALS

R.E. Graham; Bell Telephone Laboratories, Inc., Murray Hill, New Jersey

Journal & Date UNKNOWN, p. 147.

(Author's) ABSTRACT:

A system is described for digital encoding of continuous information sources based on quantizing the difference between the original continuous signal and a predicted version thereof, as opposed to quantizing the original signal itself. The coding is tailored to the observer's perception by employing fine quantum steps for the small prediction errors, and coarse steps for the large errors where the predictor, and possibly the observer, are surprised. With this tapering of the steps in the quantizing staircase, the total number of levels needed in the quantized error signal for high-quality reproduction may well be so small that a simple nonstatistical coding of the error signal will yield a substantially lowered bit rate compared with conventional systems.

To extend the accuracy of digital representation obtained with this system, an additional operation is described in which the "idle times" - the blanking intervals in television - are commandeered to allow the introduction of extra samples in difficult regions of the signal. This requires "elastic" delay of a simple type in which the delay is varied step-by-step in one direction until reset to the starting point.

A series of photographs is included showing processed pictures obtained by computer simulation of the various coding methods.

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COMMENTS:

The predictive quantizing procedure discussed by the author should in most cases require less bandwidth and should yield pictures with less quantizing noise than normal pulse-code modulation. One procedure called differential quantizing consists of quantizing the difference between the original signal and a prediction of that signal, where the prediction scheme can take one of many forms.

Two prediction schemes are discussed in this paper: in one case, the prediction is based on previous in-line sampling (one dimensional); and in the other case, the prediction is based on previous samples spatially adjacent to the sample being predicted (two dimensional).

The author suggests that the tapered quantizer staircase (non-linear quantizing) and the prediction schemes used for coding the signal yields pictures particularly suited for human observation since the resulting picture quality is considered reasonably good. Illustrations in the text compare high quality pictures quantized to 512 brightness levels with pictures quantized to eight brightness levels, and with pictures differentially quantized to eight

brightness levels by one- and two-dimensional prediction schemes. Although the three-bit differentially quantized pictures compare very favorably with the three-bit normally quantized pictures, such preference is based wholly on the subjective judgments of the author and the reader. Such preferences may not necessarily correlate with the quantity or quality of the scene information transferred from the pictures to the observer. This method of coding may yield particularly poor results with image corners or image edges or lines forming a 45 degree angle with the scanning lines, and with approximately circular images which are relatively small. These effects, and the necessity for an essentially error-free transmission of the encoded signal (predictive coding systems are exceedingly sensitive to digital transmission errors), probably make this encoding procedure a rather poor candidate for the transmission of pictorial information.

(24.100)

PCM PICTURE TRANSMISSION

T.S. Huang; Research Laboratory of Electronics, M.I.T.

IEEE Spectrum, Dec., 1965, p.57.

SUMMARY:

The author gives a brief review of the research being done on PCM picture transmission at the Cognitive Information Processing Group of the Research Laboratory of Electronics, Massachusetts Institute of Technology. The research being conducted falls into two general categories: the quality of the received picture as a function of system parameters and bandwidth compression techniques.

An experiment is described in which subjects judged the quality of PCM (pulse code modulated) pictures as a function of the number of samples in space ( $L \times L$ ) and the number of brightness levels ( $2^B$ ). Each of three pictures, which differed from each other in the amount of detail, was produced at different combinations of  $L$  and  $B$ . The number of bits required to transmit each picture is equal to  $N = L \times L \times B$ . The question asked was "For a given value of  $N$ , how should we choose values for  $L$  and  $B$  to get the best received picture?"

The subjects ranked the pictures according to their subjective quality. The results were described in the form of isopreference curves (curves on which the points represent pictures of equal subjective quality). The conclusions were:

1. The isopreference curves depart from curves of constant bit rate ( $N$ ).
2. The shape of the isopreference curve depends on the amount of picture detail. Only a few brightness levels are needed for pictures that have a lot of detail.
3. In some cases, for a fixed value of  $L$ , the picture quality improved with a decrease in the number of brightness levels. The author states that "A probable reason is that decreasing the brightness levels increases the apparent contrast of the picture."

In another experiment, the noise power of a received picture was determined for two ways of coding brightness levels and for the average of all possible codes for various values of  $B$ . The two codes were the "natural code" and the "Gray code." The results showed that..."the Gray code yields only slightly more noise power than the natural code and is better than most other codes." This result applies only if the input-amplitude distribution is flat.

The results of other experiments showed that for channels in which noise occurs in bursts (most practical channels), pseudorandom scanning will yield less objectionable pictures than does line-by-line scanning.

The remaining portion of the article is a discussion of bandwidth reduction techniques being investigated. The author suggests that the most promising technique is probably some modified form of delta modulation. One modified form called delta-squared modulation (high information delta modulation) gives much sharper pictures than delta modulation. But, if the channel is noisy, delta-squared modulation produces dark or light streaks in the scanning direction.

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COMMENTS:

The experiment most relevant to the studies we propose is that on the number of brightness levels and the number of samples in space. The variables investigated are those we propose to study, but the data reported are not useful for our purposes because the quality of the imagery was based on the judgment of aesthetic appeal and not the performance (information extraction) of observers. Furthermore, the characteristics of the photographs used was not described. Obviously, the quality of the picture observed is not only a function of the number of brightness levels and the number of samples, but of the characteristics of the original picture.

(24.11)

THE SUBJECTIVE EFFECT OF TWO-DIMENSIONAL PICTORIAL NOISE

T.S. Huang, IEEE Transactions on Information Theory, Jan. 1965, p.43

(Author's) ABSTRACT:

A study has been made of the subjective effects of the class of independent additive rectangular low-pass Gaussian noises. Three original pictures, varying in the amount of detail, were used. The general shapes of the isopreference surfaces in  $\sigma - k_1 - k_2$  space where  $\sigma$  is the rms value, and  $k_1$  and  $k_2$  are the bandwidths of the noise in the horizontal and vertical directions, respectively, were found. If the objectionability of noise is a linear functional of the noise spectrum, then one may deduce that for the class of noises whose spectra are symmetrical with respect to both horizontal and vertical frequencies, the weighting function in the integral representing noise objectionability is similar in shape to these isopreference surfaces.

Some of the author's conclusions from the study were as follows:

1. The objectionability of square noises of a fixed power has a maximum at a bandwidth of around 0.2 cycle per minute of arc and falls off toward both low and high bandwidths.
2. If the noise power is held constant and the vertical ( $k_2$ ) and horizontal ( $k_1$ ) bandwidths are increased such that the ratio  $k_1/k_2$  is constant, the objectionability of the noise will first increase, then reach a maximum, and finally decrease.
3. Noises with vertical streaks (vertical bandwidth is smaller than horizontal bandwidth) are more objectionable than noises with horizontal streaks.
4. Generally, noises which contain frequencies similar to those of the picture are less annoying.

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COMMENTS:

The author required the subjects to judge which of the noisy pictures they would rather watch by rank-ordering them. Although ranking may be an acceptable measure for the author's purposes, such measures are of limited value for determining how much information the human can extract from a picture. Furthermore, the results are plotted in terms of equivalence measures (iso-preference curves). The problem with equivalence measures based on preferences is that 1) equal preference does not imply that equal amounts of information can be extracted, and 2) differences in preferences (i.e., the differences among the isopreference curves) are not descriptive of the amount of information that can be extracted from the pictures.

This experimental work is considered to be among the best of the literature surveyed. Unfortunately, the dependent variable (preferences) is useful in application such as commercial television broadcasting, it is not directly useful in relating the informative value of images to the image characteristics.



(24.52)

OPTICAL SPOT SIZE STUDY FOR DATA EXTRACTION FROM A TRANSPARENCY

L.L. Izzo, CBS Laboratories, Stamford, Connecticut

Defense Documentation Center, September 1965; AD 628588

(Author's) ABSTRACT:

A breadboard model scanner using coherent light to generate a small optical spot for data extraction from a transparency was constructed. Using the technique developed, a capability of distinguishing 256 lp/mm and 30 shades of grey from light to dark was demonstrated. The system consists of a laser light source, a beam expander, a beam normalizer, a rotating optical scanning system to cover a 2 inch wide transparency, a transparency holder, a light collector and a photomultiplier assembly including video amplifier and high voltage power supply. These system components are basically "off-the-shelf" items.

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COMMENTS:

With the scanner described in this paper, the author demonstrated several rather well-known facts. For example, the resolution capability was related to the size of the scanning spot and the number of detectable grey levels was related to the dynamic range of the system, the size of the scanning spot as it relates to the granular structure of the transparency, and the noise characteristics of the system. Circular scanning spots were used; special efforts were made to make the scanning spot of uniform intensity over its area.

The title of this paper is somewhat misleading since several very important factors were not discussed. For example, the effect of the shape of the scanning spot on the characteristics of the extracted data is not mentioned; instead it was assumed desirable to use a circular scanning spot of uniform intensity. Likewise, there is no discussion relative to the overlap of the scan lines and its effect on data extraction or image quality. Also, no mention is made of the effects of the size and shape of the scanning spot on the quality with which images of complex shape are reproduced.

This paper describes in considerable detail the characteristics of the specific scanner which was constructed. But, it does not discuss factors of fundamental importance in the extraction of data from a transparency; for example, scanning spot shape and size, and the spatial interaction or overlap of scanning spots.

(24.49)

PRINTING BY WIRE

W. P. Jaspert

Perspective, 1966, p. 208

(Author's) SUMMARY

Some modern newspapers are set photographically. Photographs are easily transmitted by telegraphy. Facsimile transmission offers possibilities of sending complete pages by cable or wireless.

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COMMENTS:

The author examines the various picture transmission systems (picture telegraphy, facsimile) and their application possibilities in such areas as the transmission of centrally prepared papers, magazine-color transmission, meteorological information transmission home facsimile new papers etc.

In all of these systems and applications the original is scanned first, coded into electrical signals, transmitted and at the receiving end decoded and recoded by electronic or photographic means.

Since the original contains large amounts of information, it requires a large bandwidth capacity channel or a long time for transmission.

In present day installations a good compromise has been reached between bandwidth and transmission time with a 48 KC - 12 channel transmission system.

Further improvements in detail resolution, transmission speeds and recording techniques (application of fiber optic in direct recording on to film or paper) are predicted.

(24.154)

DATA COMPRESSION BY REDUNDANCY REDUCTION

C. M. Kortman; Lockheed Aircraft Corporation

IEEE Spectrum, March 1967, p.133

(Author's) SUMMARY:

Because of the increasingly pressing problem of spectrum overcrowding in data transmission channels, it is becoming more and more necessary to develop schemes to optimize the use of the available frequencies.

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COMMENTS:

The author reviews the various data compression techniques available today.

First we find the definition of terms used in the information processing field:

data compression  
parameter extraction  
adaptive sampling  
redundancy reduction  
encoding  
predictor  
interpolator

Then a classification of known data processing models is presented.

Of the many data-compression techniques the polynomial predictors and interpolators are discussed in some detail. (They give the best approximation to the real data.)

A comparison of several redundancy reduction algorithms is offered in graphical and pictorial forms. It is surprising, that even for large compression ratios and tolerance corridors, the difference between the original video signals and the reconstructed data is small.

This remark is highly subjective since there is no mention of experimental work relative to the information content of the images as a function of different data compression ratios.

(24.31)

IMAGE PROCESSING

L.S.G. Kovaszny, John Hopkins University; and H.M. Joseph, ACF Electronics  
Proceedings of the IRE, May, 1955, p. 560

(Author's) SUMMARY:

A scalar function of two independent variables can be visualized as an image. All mathematical operations can be conceived as a modification or processing of the original image. An important class of modifying operators can be realized by special scanning techniques without using a rapid access memory storage device. It was found that the two important operators so far explored may have practical importance. One is contour enhancement which has "de-blurring" effects akin to aperture correction and "crispning" in television practice; the other is contour outlining that produces a line drawing from a picture with continuous tones. The general concepts developed may also permit extension of the method to analog computers for certain classes of partial differential equations. The flexibility and adaptability of the system offer practical application whenever some predetermined operation is required on picture material.

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COMMENTS:

The authors were among the first ones to develop the theory of "image processing" through mathematical manipulation of the "image function" (vector-scalar function describing the original picture).

The "processing" itself is represented by homogenous, isotropic, linear differential and integral operators of the vector-scalar field (original picture).

"Contour enhancement", "contour outlining" operations can be performed on the original picture with the appropriate selection of these operators.

Several possible applications of these techniques are suggested by the authors:

- 1) Image transmission through reduced bandwidth channel (contour enhancement) prior to transmitting a low-definition picture to compensate for losses sustained during the transmission.
- 2) Contour outlining may be used as a means of reducing the information content of pictures, consequently lower the bandwidth requirements for transmission.

Although there are more efficient ways to reduce bandwidth or losses during transmission, these techniques warrant further investigation.

(24.41)

STATISTICS OF T.V. SIGNALS

E.R. Kretzmer

Bell System Technical Journal, July 1952, 31:751.

(Author's) SUMMARY:

Measurements have been made of some basic statistical quantities characterizing picture signals. These include various amplitude distributions, autocorrelation and correlation among successive frames. The methods of measurement are described, and the results are used to estimate the amount by which the channel capacity required for television transmission may be reduced through exploitation of the statistics measured.

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COMMENTS:

The paper describes techniques for the measurement of the following statistical characteristics of video signals:

- 1) Simple probability distribution of signal amplitude corresponding to picture brightness.
- 2) Simple probability distribution of error amplitudes resulting from linear prediction of T.V. signals. The "previous-value" prediction is considered by the author which supposes that each picture element has the same brightness level as the preceding one. The prediction-error signal is the difference between the picture signal and the reference signal.
- 3) Auto-correlation of typical pictures: measurement of the average correlation between picture elements separated by varying distances. (It is the average product of the two brightness levels of each adjacent picture-element pair relative to the average square of all brightness levels.)

The results show that if a signal is quantized into 6 amplitude levels (6 bits/sample) and all 6 levels are equally likely, the average information content/sample is about 5 bits.

The average information content from all available data is estimated by the author as 3.4 bits below the 6-bit ceiling.

The instruments and measurement techniques described in the paper are quite simple and can be useful in the investigation of statistical characteristics of picture signals.

(24.70)

THE FUTURE OF GRAPHICAL COMMUNICATIONS

T.M.C. Lance, Electronic Engineering, August, 1966,

SUMMARY AND COMMENTS:

A brief review of electronic transmission techniques of graphical data is presented in the article and the effect of the "communication explosion" is examined on future societies.

Demand for many additional forms of information transmission is predicted in such areas as personal letters, photographs, drawings (industrial, commercial and home use).

In all applications the original is scanned and synthesized by mechanical or electronic means and presented in a) TV type or other forms of display (rapid process photography, xerography), or b) digital form and stored for further processing or viewing at a later date.

( . )

IMPROVEMENT IN DIGITAL VIDEO PROCESSING BY THE USE OF NOISE

R.E. Marshall, E.K. Holland-Moritz, J.C. Dute; Radio Science Laboratory, University of Michigan, Memorandum of Project Michigan, 2900-489-R. Title and Abstract unclassified. Most other parts classified "confidential."

(Author's) ABSTRACT:

This report describes techniques for improving the quality of quantized pictorial information. The techniques discussed (1) companding (compression and subsequent expansion) and (2) adding random or pseudo-random noise prior to encoding. Particular attention is given to encoding with a few levels to determine lower limits on the code length required for the transmission of pictorial information.

Experiments were performed using random noise to remove contours. Pictures derived from two sources of infrared video illustrate the effects of quantizing, of varying the sampling rate, and of removing contours by adding noise.

Mention is made of the use of contouring to emphasize isotherms, and two photographs of ice fields are included to illustrate the application.

Further improvements in digital video processing which should be possible with the use of pseudo-random noise and companding are discussed in the Appendix.

It is concluded that the use of two or three bits of information per datum should be adequate for transmission or reproduction of many video sources if pseudo-random noise and companding are used.

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COMMENTS:

The companding techniques experimentally evaluated were not as successful as were the techniques whereby random or pseudo-random noise is added prior to encoding. Several aerial photographs were quantized at very few bit levels; the authors conclude that by adding noise prior to encoding a picture quality level is obtained which is subjectively equal or comparable to noise-free pictures quantized with a greater number of bits. However, the authors also conclude that the pictures quantized with two or three bits to which noise was added were of satisfactory subjective quality with regard to apparent grey scale, but also noted that the presence of the added noise tends to obscure small image detail.

In this experimental work, the characteristics of the aerial photographs are not reported and the subjective evaluations of the quantized pictorial information was performed by the authors only, yielding results of questionable reliability and validity.

Compared with many other papers on this topic, this is a very good technical report. If the characteristics of the original and processed pictures had been specified in greater detail, and if the processed pictures were evaluated thoroughly by sound experimental techniques, this paper would be considered excellent.



(10.29)

TARGET DETECTION USING BLACK AND WHITE TELEVISION. STUDY I:  
THE EFFECTS OF RESOLUTION DEGRADATION ON TARGET DETECTION

L.C. Oatman; Human Engineering Laboratories, Aberdeen Proving Ground, Maryland  
U.S. Army Technical Memorandum 9-65, July, 1965; AD 625231

(Author's) SUMMARY:

The experiment investigated how TV resolution affects target-detection probability. Sixteen Ss (subjects) viewed a V-48 tank on a closed-circuit black-and-white TV system under four levels of resolution (800, 600, 400, and 300). The Ss' task was indicating in which one of nine areas the tank appeared.

The data indicate that Ss' target-detection probability decreases significantly between the 300 and 400 levels of resolution (the target detection probability was lower for the 300 level of resolution); however, there was no significant differences among the 400, 600, and 800 levels of resolution. In addition, the target's location on the TV screen affected the target-detection probability significantly; however, this effect was confounded with resolution, luminance, and Ss' search techniques.

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COMMENTS:

The four levels of resolution described by the author were obtained by changing the horizontal bandwidth (the bandwidths were 20.0, 6.0, 1.7, and 1.0 megacycles) of an 875-line TV system and holding the vertical resolution constant (650 lines).

The author states that "Although it was expected that reductions in bandwidth and/or resolution would affect the probability of target detection, it is interesting that the relationship between resolution and target detection probability is non-linear." In our opinion, one would expect either no relation or a "non-linear" relation between detection performance and the resolution values used in this study. We believe that if the subjects were given sufficient time to look at the TV screen, detection performance could probably have been perfect under the 800, 600, and 400 line resolutions. Instead, their performance under these three highest resolutions was less than perfect because they were shown a picture for only 0.5 seconds. In other words, the subjects' detection performance was limited at the three highest resolutions by the time given to search the TV screen. The 300-line condition was of sufficiently poor quality, particularly considering that the resolution was even lower at the corners of the screen, to slightly lower detection performance.

The data from this study are of limited use because there is no way of relating the performance of the subjects to the quality of the displayed picture. Although the resolution at the TV screen is specified, the characteristics of the photograph was not specified. One would have to know the characteristics of both the TV system and the photograph to properly describe the displayed picture.

(10.32)

TARGET DETECTION USING BLACK-AND-WHITE TELEVISION. STUDY III:  
TARGET DETECTION AS A FUNCTION OF DISPLAY DEGRADATION

L.C. Oatman; Human Engineering Laboratories, Aberdeen Proving Ground, Maryland

Technical Memorandum 12-65, September, 1965; AD 627009

(Author's) SUMMARY:

Two previous studies have examined the probability of detecting an M-48 tank on a black-and-white close-circuit television (TV) system, with apparently conflicting results. When only horizontal resolution was reduced to get resolutions of 300, 400, 600, and 800 lines, detection performance was essentially the same for the three highest resolutions, though significantly poorer for the 300-line resolution. Yet when resolution was reduced in both horizontal and vertical dimensions, 800-line resolution gave better detection performance than 450-line resolution did. Extraneous variables that could not be controlled--such as uneven brightness and resolution on the TV monitors themselves--made it difficult to interpret these results. Thus it was not clear whether the first result was an unlikely chance event or whether resolution's effect depends on the number of dimensions reduced. The present study replicated the first one to test its verifiability.

Displays at all four levels of resolution were presented to 20 subjects, who were asked to indicate in which one of nine areas the tank appeared on the TV screen. The results verified those of the first study: the subjects detected targets about equally well with the 800-, 600-, and 400-line resolutions, but their performance was significantly poorer with 300-line resolution. This finding suggests that, if resolutions are equal, reducing both horizontal and vertical dimensions will impair detection performance more than reducing just horizontal resolution (i.e., reducing bandwidth). The effects of the tank's location on the TV screen, although probably an important determinant of target-detection probability, again proved impossible to isolate from various extraneous variables.

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COMMENT:

The same comments on the author's first study also apply to this study.

(10.28)

TARGET DETECTION AS A FUNCTION OF EXPOSURE TIME AND DISPLAY MODE

L. C. Oatman; Human Engineering Laboratories, Aberdeen Proving Ground, Maryland

U. S. Army Technical Note 8-63; October 1963; AD 431118

(Author's) SUMMARY:

Ten Ss (subjects) were tested in an investigation to compare an operator's ability to detect targets on a television and rear-projection screen. Mode of presentation, slide or TV, was investigated as a function of exposure time, 0.3 second, one second, and five seconds.

The results indicated a significant difference between modes of presentation and exposure times, with a significant interaction between mode of presentation and exposure time. It was suggested that the differences in the number of target locations (detections) between the TV and slide presentations may be attributed to the poorer resolution of the TV system. Further investigations should be made to determine more adequately the relationship between the mode of presentation and exposure time.

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COMMENTS:

The author states that "The purpose of this study was to examine the operator's ability to detect the location of targets on a closed-circuit TV screen and a slide-projector screen as a function of exposure time. The procedures applied to the TV-monitor display in order to obtain baseline data which were predicted to be comparable to data from other studies using screen displays."

Our opinion is that the data obtained in this study are of very limited use for establishing a "baseline" because the characteristics of the photography used were not specified. Consequently, performance on both the slide-projector and TV conditions cannot be related to the characteristics of the displayed picture.

The author's prediction that "... (1) location scores from the slide display would be significantly better than the location scores from the TV display..." seems rather trivial. This result is predictable from the resolutions of the back-projection screen and the TV system. If the author's intent was to compare a specific screen and TV system, this intent was not stated nor implicit in that the characteristics of back-projection screen were not specified.

No TV-system parameters were varied in this study so the data cannot be used to establish the optimal values of such parameters.

(10.31)

EFFECTS OF TELEVISION BANDWIDTH ON TARGET IDENTIFICATION

D. Shanahan; U.S. Naval Missile Center, Point Mugu, California

Technical Memorandum No. NMC-TM-64-2, April, 1964

(Author's) SUMMARY:

A laboratory test program was conducted to evaluate the effects of video signal bandwidth and target contrast ratio on visual target identification. The targets were observed on the monitor of a closed circuit television system. A zoom lens was used to simulate motion. The tests were designed to idealize the operation of a possible television command guidance missile system. To eliminate undesired test variables, the targets were Landolt rings of known sizes and contrast ratios.

The results of the tests indicate that:

1. Reducing the target contrast ratio degrades target identification abilities.
2. Reducing the video signal bandwidth degrades target identification abilities.
3. The ability to identify targets is degraded less by video bandwidth reductions for low contrast targets than it is degraded by high contrast targets.
4. The ability to identify targets is degraded less by target contrast ratio reductions when using a narrow video bandwidth rather than using a wide video bandwidth.

Because a narrow bandwidth requirement means an increase in transmission range, and because most targets exhibit a low contrast ratio to an airborne television system, it is suggested that a trade-off may exist for increasing the performance of a guidance system in a marginal range situation.

It is emphasized that, because of the highly idealized parameters used in the tests, the results are no more than indicative and are not to be considered as suitable as working values for a television guidance system. The real value of the results is in pointing out a promising avenue of effort.

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COMMENTS:

The subject's task was to report the position of the gap in an Landolt ring, a commonly used task for measuring visual acuity, although the title implies that the subject was required to identify different kinds of targets. Another study (Freeberg) referred to in this review shows that measures obtained

The most interesting finding in this study is that measures of pattern acuity (the location of a gap in a Landolt ring) did not correlate with form recognition or form discrimination thresholds. (This finding is consistent with others that indicate a very low correlation - about .20 - between acuity and form recognition measures.) The implication of this finding is that acuity measures should not be used as a dependent measure in evaluating system parameters when the investigators are interested in image (form) recognition.

( . )

SECURE COLOR VIDEO TECHNIQUES

C.F. Teacher and R.W. Yutz, Technical Report No. RADG-TDR-64-339, Feb., 1965; AD 462528, Unclassified; restricted distribution.

(Author's) ABSTRACT:

This report examines and compares the merits of many analog matrixing techniques for color television, efficient video digital encoding techniques, color video pick-up devices, and color display devices. Tradeoffs between picture quality and data rates are examined for both briefing and surveillance applications. The color systems investigated include NTSC, field sequential, two-color, equal band and SECAM. The efficient digital encoding systems investigated include delta modulation (single and multibit; linear and exponential), PCM pseudo-random noise, split-band delta modulation, dynamic delta, and block classification. It was found that digitally encoded NTSC systems are not necessarily best for military applications. A new system called LADECOLOR (Line Alternated Digitally Encoded Color) that includes some of the principles of the NTSC and SECAM systems plus the efficiency of delta modulation and data modems was found to be more effective. This new system will not become obsolete since it can incorporate advanced redundancy reduction techniques as they are developed.

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COMMENTS:

During this six-month program, described in this report, the authors attempted to find efficient digital color television standards by which pictures of high quality could be transmitted at low-bit rates. Much of the work was of an analytical nature; several experimental tasks were performed in which combinations of basic color TV systems and efficient digital and coding techniques were evaluated and compared to the NTSC system. Specific bandwidth reduction techniques and combination of bandwidth reduction schemes were examined. A literature search was also performed.

Selected pictorial data encoding techniques were examined in an experimental facility with provisions for image manipulation by flying spot scanner and photographic techniques. The resulting pictures were evaluated subjectively by the authors and formed the basis of the authors' recommendation for the Ladecolor system.

Although this report contains much technical data on many television systems, the resulting recommendation for a system is based primarily on analytical reasoning. The experimental work was not sufficiently detailed, the characteristics of the original photographs are not described in sufficient detail, and the evaluation of the experimentally processed images was not adequate enough to be considered in the selection of a system, nor additional experimental work.

(24.93)

PICTORIAL TRANSMISSION WITH HIDM

M. R. Winkler, Radio Corporation of America, Communications Systems Division, Tucson, Arizona

Digest of Technical Papers of 1964 International Symposium on Global Communications, Session 15.4, p. 91.

(Author's) SUMMARY:

High Information Delta Modulation, HIDM, is a new pulse coding technique able to efficiently encode pictorial data with as little as three pulses per picture element and adequately provide those picture characteristics which are required by the visual mechanism.

HIDM has been used to transmit pictures between facsimile transmitters and recorders using three pulses per picture element and providing quality comparable to six or seven bit PCM. The same technique can be extended to TV picture transmission.

HIDM can transmit pictures with half the bandwidth or pulse rate of PCM and a third the bandwidth or pulse rate of conventional DM. It is not troubled with contouring or slope limiting.

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COMMENTS:

High Information Delta Modulation is a most interesting technique for pictorial transmission. As discussed in this paper, this technique is similar to Delta Modulation, but the increment that is added to the signal as it is regenerated is varied in accordance with the rate at which the signal is varying. This technique has two major advantages: it requires less bandwidth than pulse-code modulation, and it does not exhibit quantizing noise characteristics. High Information Delta Modulation provides better image quality than straight Delta Modulation; this is particularly true since greater dynamic ranges and greater signal slope gradients can be obtained with High Information Delta Modulation as compared to straight Delta Modulation.

No major disadvantages of the use of High Information Delta Modulation techniques are mentioned in this paper. However, it may be that the overshoot accompanying sharp image edges may yield undesirable edge effects. Whelan\* reports that this technique suffers somewhat from a jitter phenomenon that produces an effect similar to a slightly noisy horizontal sinc signal in a conventional television display, and shows up near edge information or rapid transitions in the pictures and distorts such high-frequency information as small lettering.

The paper presents a figure in which two pictures are compared--one picture was transmitted by facsimile with direct line connection; while the other picture was transmitted through a high-information Delta Modulation link.

Although the two pictures compare favorably, such a comparison is really not valid since no information is presented in the paper on the characteristics of the facsimile direct-line transmission.

The major conclusion made in this paper is that high-information delta modulation is an efficient coding technique having distinct advantages over conventional pulse-code modulation or delta modulation. Two reasons are given for this: first, it is able to encode picture information with as little as three pulses per picture element; and, secondly, because its capabilities inherently match the visual requirements of the eye. The first-mentioned reason is described in detail, but no detailed information is given which substantiates the conclusions that its capability inherently matches the visual requirements of the eye.

\*Whelan, J.W., J. Spacecraft, 3:667 (1966)



APPENDIX B

REFERENCES READ - NO COMMENTS INCLUDED

References include author's abstracts, when available, and are given in alphabetical order of (Senior) author's name. The numbers in parentheses are for our filing purposes and should be disregarded.

(24.151)

LINEAR AND ADAPTIVE DELTA MODULATION

J..E. Abate, Proceedings of the IEE, Vol. 55, No. 3, March 1967

(Author's) ABSTRACT

New results are presented, offering insight into the performance and optimization of linear and adaptive delta modulation, together with a comparison with pulse code modulation. The results are applied to three cases of practical interest: television, speech, and broadband signals.

The results are presented as follows: first, a characterization of the quantization noise of linear delta modulation (DM) is given; second, an adaptive DM system which seems promising for television and speech is evaluated; and third, a comparison between PCM and adaptive DM is made for speech, television, and broadband signals.

It is concluded that 1) the adaptive system provides DM with a companding capability, 2) adaptive DM offers a bit rate or channel bandwidth reduction capability in comparison with PCM for television signals, 3) adaptive DM appears better suited to television and speech signals than linear DM, 4) the maximum S/N performance of adaptive DM is the same as that of linear DM, 5) the companding improvement offered by adaptive DM is not limited by the same practical considerations as those of PCM, and 6) the S/N performance of adaptive DM is the same for both Gaussian and exponential signal densities.

(24.159)

A SYSTEM OF AUTOMATIC CONTOUR DISPLAY (AUTOCON)

W. W. Anderson, AD 417193

(Author's) ABSTRACT

A newly developed system of Automatic Contour Display, entitled AUTOCON, receives analog information from a plane of equally spaced data points and simultaneously converts this information into complete contour response surface plots. The system employs a series of analog storage, scanning, and interpolation operations which take a finite number of data points in a plane and, from them, generate an interpolated surface over all these points. As the surface is generated, it is quantized into discrete contour levels which are then drawn on a stored television display for immediate use and on 35mm film for a permanent record.

(24.159) Continued

The present AUTOCON system can accept individual data points at a rate of ten readings per second and will plot a contour consisting of eleven, electronically-identified, distinct, contour levels. The complete system, as well as certain individual portions, is generally applicable to any area of investigation which uses contour-response surface plots or similar displays as a method of graphical analysis. The system's chief advantage in its present use of stray magnetic field investigations is the elimination of the time required to obtain contour displays of 1 or 2 hour by manual plotting. Immediate viewing of the magnetic field data in contour form results, then, not only in a decrease of experimentation time, but also in an increase of experiment validity and flexibility.

(24.146)

ADAPTIVE DATA COMPRESSION

C. A. Andrews, J. M. Davies and G. R. Schwarz, Proceedings of the IEEE, Vol. 55, No. 3, March 1967

(Author's) ABSTRACT

Data compression techniques are classified into four categories which describe the effect a compression method has on the form of the signal transmitted. Each category is defined and examples of techniques in each category are given.

Compression methods which have received previous investigation, such as the geometric aperture methods, as well as techniques which have not received much attention, such as Fourier filter, optimum discrete filter, and variable sampling rate compression, are described. Results of computer simulations with real data are presented for each method in terms of rms and peak errors versus compression ratio.

It is shown that, in general, the geometric aperture techniques give results comparable to or better than the more "exotic" methods, and are more economical to implement at the present state-of-the-art. In addition, the aperture compression methods provide bounded peak error which is not readily obtainable with other methods.

(24.146) Continued

A general system design is given for a stored-logic data compression system with adaptive buffer control to prevent loss of data and to provide efficient transmission of multiplexed channels with compressed data. An adaptive buffer design is described which is shown to be practical, based on computer simulations with five different types of representative data.

(24.122)

DIGITAL DATA PATTERN DISPLAY SYSTEM

Edward J. Armata

IEEE Transactions on Aerospace-Support Conference Procedures

(Author's) SUMMARY

This paper describes a data processing and display system that graphically represents digital data transmitted from a spaceborne vehicle in such a way that the operation of the payload can be rapidly evaluated. The digital data is converted to analog form and is presented in a pattern of dots and special symbols, representative of digitally coded information, in an X-Y coordinate form on a cathode-ray tube. The digital data processing system is described, but emphasis is placed on the data storage system and the attendant circuits. The storage medium used in this system is high-resolution scan-conversion tubes, which allow simultaneous write-in and readout. The data, which can be asynchronous, is read out by a high-resolution TV-type scanning and monitor system. The use of the scan-conversion tubes affords the most advantageous combination of storage capacity, storage time, short access time, and equipment economy.

(24.56)

TELEVISION SYSTEM FINAL REPORT - PIONEER II

Stuart C. Baker, Space Technology Lab Report GM-00-4110-00549, December 1958

**NO ABSTRACT**

(24.86)

VIDEO TRANSMISSION BY DELTA MODULATION USING TUNNEL DIODES

J. C. Balder & C. Kramer, Proceedings of IRE, April, 1961

(Author's) SUMMARY

A method is described which enables video signals to be transmitted by the pulse code modulation system known as delta-modulation. A tunnel-diode balanced pair (Goto pair) is used for converting the video signal into a binary signal. With a new and very simple circuit, operating at a bit rate of 100 Mc, a ratio of signal-to-quantizing noise of 42 db is obtained. A more conventional circuit, that combines tunnel-diodes with transistors, makes an even lower quantizing noise possible.

(24.52)

TRANSMITTING VISUAL INFORMATION

D. A. Bell, Perspective 8 #3 1966

NO ABSTRACT

(24.150)

STATISTICAL DELTA MODULATION

P. A. Bello, R. N. Lincoln and Herbert Gish, Proceedings of the IEEE, Vol. 55, No. 3 March, 1967

(Author's) ABSTRACT

This report describes the results of a study of Statistical Delta Modulation (SDM), a new method of digital transmission of analog information. In this method the system design is tailored to the statistical properties of the input data so as to provide analog reconstruction values with a minimum mean squared error. The method of system design is an iterative procedure in which conditional means are evaluated based upon actual input data. The report presents the theory of operation of the system and describes the results of a computer simulation in which such questions as the effects of sampling rate, channel noise, system memory, and mismatched input processes are discussed. At the present time only a brief comparison has been made with

(24.150) continued

conventional techniques. It was found that at low sampling rates and for a particular non-Gaussian process, sampling rate reductions of 38 percent could be achieved relative to a conventional delta modulation system at the same SNR performance.

(24.51)

PROCESSING RANGER AND MARINER PHOTOGRAPHY

Fred C. Billingsley, SPIE Journal, 4:147, April/May 1966

(Author's) ABSTRACT

A discussion of the "Lunar Television Image Converter" (Lunar TIC) will be presented. This is the system utilized for the digital processing of the RANGER and the MARINER pictures. Digitizing requirements and "tradeoffs" will be covered as they apply to this process which employs a magnetic analog tape as the data source, converts the data for processing in a 7094 computer and then converts it to picture form. Some of the RANGER and MARINER pictures which have been processed in the JPL digital computer will be shown and the various techniques used will be discussed. Samples will also be shown of the capability of Lunar-TIC to scan, digitize, and reconstruct photographic transparencies.

(24.110)

THE IMPROVED GRAY SCALE AND THE COARSE-FINE PCM SYSTEMS, TWO NEW DIGITAL TV BANDWIDTH REDUCTION TECHNIQUES

W. T. Bisignani, G. P. Richards, and J. W. Whelan, IEEE Proceedings, Vol. 54, March 1966

(Author's) ABSTRACT

Two new digital television bandwidth-reduction techniques are presented with experimental results. Each provides twice the efficiency of a conventional pulse code modulation (PCM) system with similar picture fidelity, and each is simple and feasible for present-day spacecraft Implementation. The Improved Gray Scale PCM system effectively eliminates, by an averaging process, the gray scale contouring effect encountered in low-bit digital TV systems. The Coarse-Fine PCM system is somewhat more complex, but provides a higher fidelity

(24.110) Continued

reproduction of the original picture. The basic principles of operation of these two new data-compression techniques are given along with comparative pictorial results.

(24.102)

UNIVERSAL ASYNCHRONOUS SCANNING AND DIGITIZING SYSTEM FOR TELEMETRY DATA SOURCES

R. W. Bivans, F. T. Innes, G. D. Matthews, National Telemetry Conference  
Los Angeles, California, June 2-4, 1964, Proceedings

(Author's) ABSTRACT

A new ground digitizing system is described which links 16 asynchronous sources of PCM and PAM telemetry data, along with sampled and time multiplexed outputs from FM subcarrier discriminators, to a digital computer for data reduction and for real-time control during count-down and launch operations. As part of a major NASA telemetry ground station at Cape Kennedy, the new system provides the computer with random access to any of 2048 data channels, with simultaneous provision for analog recording of any 64 channels. The system is described with emphasis on performance and the problems posed by asynchronism. Programming of the on-line computer is discussed. Results of operation during Centaur and Saturn launches are presented.

(24.168)

A COMPUTER-AIDED INSTRUMENTATION SYSTEM FOR STUDIES IN TACTUAL PERCEPTION

J. C. Bliss and H. D. Crane, National Aerospace Electronics Conference,  
Dayton, Ohio, May 11-13, 1964, Proceedings

(Author's) ABSTRACT

A system consisting of a small digital computer, special electronic equipment, and an array of tactile stimulators has been developed for investigation of human perception of spatial-temporal patterns displayed tactually. This system can present tactual patterns consisting of up to 96 stimulators according to several scan routines, present a number of patterns in sequential order, and record and tabulate the subject's responses.

This system as well as results from some initial experiments on tactual pattern perception are described.

(24.80)

DOT SYSTEMS OF COLOR

W. Boothroyd, Electronics, December 1949

(Author's) SUMMARY

Recent advances involve the application of new sampling and multiplexing techniques for efficient transmission of information through systems having a limited frequency band. These have important implications for the television industry, especially in connection with color television systems.

(24.178)

STUDIES OF DISPLAY SYMBOL LEGIBILITY PART II: THE EFFECTS OF THE RATIO OF WIDTHS OF INACTIVE TO ACTIVE ELEMENTS WITHIN A TV SCAN LINE AND THE SCAN PATTERN USED IN SYMBOL CONSTRUCTION

B. Botha, and D. Shurtleff, AD 420010

(Author's) ABSTRACT

The purpose of the present study was to investigate the effects on legibility of several factors characteristic of linear scan methods (TV raster) of symbol construction and display. These factors were: (1) The ratio of the widths of inactive to active elements within a TV scan line, (2) the scan pattern (the path of the scan element over the symbol) used in symbol construction. This study represents a continuation of an earlier study in which the effects on legibility of the number of linear scan constructions per symbol height were examined. A second purpose of the present study was to determine whether the method of symbol illumination (reflected light vs. transilluminated light) had an effect on legibility. Two groups of subjects viewed tachistoscopically transilluminated capital letters at a .03 sec. exposure for each of three different ratios of the widths of inactive to active elements within a TV scan line. Each group viewed letters constructed by a different scan pattern. The results showed that both accuracy and speed of response in letter identifications decreased as the ratio of the widths of inactive to active elements increased. The scan pattern used in the construction of letters had a progressively greater effect on response accuracy as the ratio of the widths of inactive to active elements within a TV scan line was increased. The method of symbol illumination had no effect on either response accuracy or speed.



(24.75)

DELTAMODULATION FOR CHEAP & SIMPLE TELEMETERING

F. K. Bowers, IRE Transactions on Space Electronics & Telemetry, December 1959

(Author's) SUMMARY

Deltamodulation is a simple binary pulse transmission method that can be readily adapted to transmit dc signal levels. It is particularly useful where only a few channels are to be sent, and where one per cent accuracy suffices. A signal-channel demonstration system has been built and tested. The high-speed limitation of such a system takes the form of a finite rate-of-rise, well suited to most telemetering. If, on the other hand, sudden large signal changes are expected, then the system may be modified accordingly. The modified system has the interesting property of giving accuracy varying exponentially with the pulse rate (as in PCM), but still without the necessity of framing the pulses.

(24.123)

GRAPHICAL-DATA-PROCESSING RESEARCH STUDY AND EXPERIMENTAL INVESTIGATION

A. E. Brain, et al, AD 637022, July 1966

(Author's) ABSTRACT

The hardware, software, techniques, and experience that were developed under the preceding Contract DA 36-039 AMC-03247(E) are briefly reviewed and are used in assessing the subject matter for further experiments. The criteria given most weight in evaluating the various types of graphical data are that the symbols be hand-drawn, that they be produced by a writing instrument that gives strokes of appreciable width, and that they occur in a situation that requires selective attention and the use of context. They are to appear in a free-field--i.e., a field without boundaries or special reference marks. The subject matter selected was computer coding sheets, where the computer language determines the character set and contextual relationship; the chosen programming language was FORTRAN.

A special input system has been built and tested, and some initial results on reading coding sheets are reported.

B8

The conclusions that have been drawn regarding preprocessor design from the experiments with the 1024-image preprocessor are briefly summarized; our present position is that we would like to use sample areas covering 0.1% to 1% of the field in our property detectors, and to have at least 10,000 samples.

The limitations of the existing preprocessor in relation to the new requirements are discussed and the constants of two possible designs based on multiple cathode-ray tubes and tubes with a fiber-optic faceplate are examined.

(24.124)

GRAPHICAL-DATA-PROCESSING RESEARCH STUDY AND EXPERIMENTAL INVESTIGATION

A. E. Brain, et al, AD 627335 October 1965

(Author's) ABSTRACT

The experiments on the recognition of hand-drawn military map symbols, using the edge-detector mask plate in the 1000-image preprocessor, have been continued with each image being displayed in a series of 9 positions, plus a 10th view with the image somewhat larger. This gave a data set of 4050 patterns; 3240 were used for training, 810 for testing. The error rate was relatively higher for the training data as compared with previously reported results, but relatively lower for the test data. The piecewise linear structure performed significantly better than the committee machine.

A brief account is given of the method used to display the characteristics of the Dot Product Units in MINOS II.

The shift-register interface between the TV camera and the SDS 910 has now been completed and is operational. Illustrations are shown of the normal picture, quantized picture, 120-line stored picture, and 24-line stored picture for the map symbols used in the tests described above.

(24.143)

SUBJECTIVE EVALUATION OF PCM NOISE-FEEDBACK CODER FOR TELEVISION

R. C. Brainard, Proceedings of the IEEE, Vol. 55, No. 3, March 1967

(Author's) ABSTRACT

An optimization of a PCM coding system has been evaluated. The system consists of a linear signal predistortion filter, a linear network in a noise-feedback loop around the quantizer, and a linear reconstruction network. Synthesis procedures for these filters to minimize the rms weighted noise have been reported.

Results of a program of subjective testing show that the subjectively optimum system is nearly the same as that predicted theoretically. With a sampling frequency of twice the signal bandwidth and three-bit quantization, the optimum system gives nearly a 12-dB improvement in subjective signal-to-weighted-noise ratio over a conventional quantization system with no filtering.

(24.3)

IMAGE QUALITY ENHANCEMENT

R. W. Brainard, and G. N. Ornstein, AD 616895, April 1965

(Author's) ABSTRACT

A technique for enhancing the quality of imagery was investigated. The technique consists of obtaining a video signal from a transparency and adding to this signal its first and/or second derivative(s). The efficacy of the technique was evaluated by comparing imagery produced by the video signal and its derivatives(s) with imagery produced by the video signal alone. The imagery investigated consisted of standard test patterns and aerial photographs. The processed test patterns were quantitatively analyzed to determine the resolution, contrast and acutance of the imagery. The results indicate: (1) differentiation enhances image quality, as indicated by the resolution, contrast and acutance metrics, (2) greatest enhancement is produced by operations which include second-order differentiation, and (3) the least enhancement is produced by first-order differentiation. The aerial photographic imagery shows the same enhancing effects as those obtained with the test patterns.

(24.30)

STUDIES OF CORRELATION BETWEEN PICTURE QUALITY AND FIELD STRENGTH IN THE UNITED STATES

C. M. Braum and L. L. Hughes, Proceedings of the IRE June 1960

(Author's) SUMMARY

The purpose of this paper is to present data which correlate a given level of picture quality with some corresponding level of measured field strength. The data were gathered by actual house-to-house surveys in conjunction with field strength measurements. This procedure was followed rather than making laboratory tests on new receivers because it was desired to evaluate coverage as it actually was, not as it ought to be. Particular attention was paid to differences between UHF and VHF channels with respect to receiver and antenna performance in given field strengths. The ranges of field strengths required for a passable picture quality are fairly well established for each band of television channels.

(24.121)

OPERATIONAL PROCESSING OF SATELLITE CLOUD PICTURES BY COMPUTER

C. L. Bristor, W.M. Callicott, & R. E. Bradford, Monthly Weather Review, Vol. 94  
No. 8, August 1966

(Author's) ABSTRACT

This survey paper explains currently applied procedures whereby operational products are formed from digitized satellite cloud pictures. Sufficient details are provided so that prospective users of the products may understand how they are produced. Comments on the outlook for digital product embellishments and augmentations are provided.

(24.163)

METEOROLOGICAL PRODUCTS FROM DIGITIZED SATELLITE VIDICON CLOUD PICTURES

C. L. Bristor & W. M. Callicott, Manuscript Report No. 26, U. S. Weather Bureau  
National Weather Satellite Center, March 1964

(Author's) ABSTRACT

Procedures are described whereby digitized vidicon cloud photos will be computer processed. Data rates, preprocessing as well as rectification and mapping are discussed and problem areas are indicated. The kinds of output are described and products from various display devices are provided through checkout samples.

(24.175)

A METHOD FOR MEASURING THE SPATIAL-FREQUENCY RESPONSE OF A TELEVISION SYSTEM

Earl F. Brown, Bell Tele. Labs., Soc. of Motion Picture and Television Engineers,  
April 16/21 1967 Conference

(Author's) SUMMARY

A simple method for obtaining quantitative measurements of the dynamic response of a television chain to spatially distributed light input signals is described. The major improvement over existing techniques is in the method of scanning the target and the ability to make rapid quantitative measurements of the system's response to almost any spatially distributed input light signal. The measurement of a television system's response to spatially distributed light input signals such as sine waves, square-waves, step or impulse signals is described and/or illustrated. Adaptation of this technique for measuring the line-profile of a picture tube is also described.

The apparatus required for these measurements is available in most well equipped television laboratories and the measurement procedure is not unfamiliar to television engineers.

(27.18)

A SLOW-SCAN TELEVISION FILM RECORDER

Henry Canvel, Journal of the SMPTE, Vol. 74, 770, September 1965

(Author's) SUMMARY

A special-purpose film recorder has been designed for recording Mariner 64 television images on 35mm film. Design problems associated with the slow-scan nature of the recorded information are discussed with regard to scope phosphors, film types and processing. Recorder operation is described, along with application information in support of Mariner Mars 1964 spacecraft TV instrumentation.

(24.84)

A PROBABILISTIC MODEL FOR RUN-LENGTH CODING OF PICTURES

Jack Capon, IRE Transactions on Information Theory, December 1959

(Author's) SUMMARY

A first-order Markoff process representation for pictures is proposed in order to study the picture coding system known as run-length coding (differential-coordinate encoding). A lower bound for the saving in channel capacity is calculated on the basis of this model, and is compared with the results obtained by previous investigators. In addition, this representation is shown to yield an insight into the run-length coding system which might not otherwise be obtained. The application of this probabilistic model to an "elastic" system of run-length coding is also discussed.

(24.79)

VIDEO TRANSMISSION OVER TELEPHONE CABLE PAIRS BY PULSE CODE MODULATION

R. L. Carbrey, IRE, 1546, September 1960

(Author's) SUMMARY

An experimental seven digit pulse code modulation (PCM) system has been built for the transmission of monochrome and color television signals over seven pairs of 22-gauge exchange area telephone cable, installed in the laboratory. A beam coding tube converts the signal to seven parallel digits of a binary Gray code at a 10 mc rate. All circuits except the coding tube deflection amplifier are transistorized. The coded digits are sent over the cable in parallel form with alternate groups converted to complements of the coded signal, thus substantially removing the low frequency component. This makes it possible to use simple repeaters without special compensation for duty factor variation. A repeater group is used after every 3000 foot section of cable. One ten megabit repeater, consisting of an amplifier and blocking oscillator, is required for each digit. All seven digit repeaters are retimed with a common timing wave. At the decoding terminal, transmitted complements are restored to Gray code before translation to natural binary. A binary weighted resistance network decoder converts the signals to a quantized reproduction of the video signal. Good quality composite color and monochrome pictures are obtained with six digits. Seven digits are believed to be necessary for broadcast quality with some margins. Waveform photographs illustrate the various functions, and photographs of decoded pictures are shown.

(24.140)

RESULTS OF A PROTOTYPE TELEVISION BANDWIDTH COMPRESSION SCHEME

Golin Cherry and A. H. Robinson, Proceedings of the IEEE, Vol. 55, No. 3, March 1967

(Author's) ABSTRACT

The transmitter/receiver system for bandwidth or data-rate compression of television signals, described herein, is a prototype model of the experimental system of Cherry et al. (1). The system is suitable for both black-and-white or half-tone pictures, in realistic noise conditions. The system parameters may be adjusted so that an optimum run-length encoding may be found; the great advantages of run-length quantizing are shown, especially with regard to practical instrumentation, leading to the use of buffer stores of modest capacity. One particular cheap form of receiver operates on a quantized-variable-velocity principle and, being much more simple and cheap than the transmitter, is suitable for use in situations requiring many receivers.

(24.87)

AN EXPERIMENTAL STUDY OF THE POSSIBLE BANDWIDTH COMPRESSION OF VISUAL IMAGE SIGNALS

Colin Cherry, M.H. Kubba, D. E. Pearson & M. P. Barton, IEEE, November 1963

(Author's) SUMMARY

It is a fact that the eyes are used far less often than the ears in telecommunication systems. The obvious reason for this is that an adequate signal can usually be obtained in aural communication channels with relatively little data, but in contrast the eyes are considered to require a very great deal of data in order to receive an adequate signal. There may be very many industrial applications of a visual communication system if only the data could be greatly reduced for such channels, so that adequate pictures of various kinds might be transmitted and received in relatively narrow bandwidths. Again, the criteria by which we judge these two kinds of channel are very different; we regularly make use of aural channels which are highly distorted and noisy, whereas we frequently judge vision channels, facsimile, etc., at very high levels of quality, presumably because we are conditioned by the needs of domestic television.

This paper, together with an accompanying paper by Kubba,<sup>1</sup> describes experiments upon the possibilities of automatic data reduction or bandwidth compression of visual channels, for both black and white diagrams and for half-tone pictures, using electronic equipment and accepting realistic noise levels.

(24.24)

AN EXPERIMENTAL STUDY OF THE POSSIBLE BANDWIDTH COMPRESSION OF VISUAL IMAGE SIGNALS

Colin Cherry, M. H. Kubba, D. E. Pearson & M. P. Barton, IEEE 1963

(Author's) SUMMARY

Same as (24.87 above)

(24.74)

SOME POSSIBILITIES FOR THE COMPRESSION OF TELEVISION SIGNALS BY RECODING

E. C. Cherry, D.Sc., and G. G. Gouriet, Paper No. 1401, Radio Section, July 1952

(Author's) SUMMARY

The paper describes first the excessive redundancy in television signals, using the term in the sense of communication theory. The information in a picture is largely contained in the edges and boundaries, but in practice these occupy a very small part of the total area. The unequal probabilities of signal elements lying in boundary and smooth surface regions are considered, together with the transition probabilities between adjacent elements. Compression is shown to be possible by making such probabilities more nearly equal, using a system of recoding.

Such recoding may be achieved by a variable-velocity scanning system if the scan velocity is made high for all regions of the picture having low picture-detail and low for regions having high picture-detail. Picture-detail is defined precisely and measured values are given from observations on working programme material.

Finally, compression is shown to be theoretically attainable in both the vertical and the horizontal directions. Correlation between successive line-scan waveforms is interpreted in terms of transition probabilities, and again a redundancy is seen to exist. Suggestions are made for reducing this by storage of every successive frame and scanning alternately in the horizontal and vertical directions, in both cases using a variable-velocity system. Finally, the paper should not be read as describing an existing working system, but purely as a discussion of possibilities.

(24.69)

A QUANTISING HALF-TONE GENERATOR FOR FACSIMILE RECORDING

H. A. Cole, United Kingdom Atomic Energy Authority Report AERE - R 4878, 1966

(Author's) ABSTRACT

An electronic unit is described which enables the amplitude of a continuously varying analogue signal to be quantised into six pre-selected channels within the range 0 to (+) 10v. The boundaries of the channels are defined by six discriminators which are connected via logic circuits to control the conduction of six associated current generators. The currents produced by the generators are used to produce a half-tone record on the



(24.69) Continued

chart of a facsimile recorder. By pre-setting the generator currents to represent a given amplitude channel, a quantised facsimile of the analogue signal may be produced in the form of a half-tone recording.

(24.132)

SPECTRAL LINES

C. C. Cutler, IEEE Spectrum, March 1967

No Abstract

(24.85)

DIGITAL SIMULATION IN RESEARCH ON HUMAN COMMUNICATION

E. E. David, Jr., Proceedings of the IRE, January 1961

(Author's) SUMMARY

Digital simulation is a powerful tool in uncovering the basic properties of new or proposed communications principles, particularly those involving coding of visual or auditory information. Operating on digitalized speech or pictorial signals, a stored program computer can perform processing equivalent to any coding. The output signals so produced can then be made available for subjective evaluation, thereby removing the necessity for premature instrumentation to produce samples for viewing or listening. This technique owes its efficacy to 1) the availability of computers fast enough to accomplish the processing in a reasonable time scale, 2) the existence of high quality translators to implement the flow of continuous signals in and out of the computer, and 3) the creation of compiling programs which allow uninitiated investigators almost immediate access to computer facilities, and which keep programming effort low. Simulation is assuming an increasing role in communications research.

(24.21)

DIGITAL SIMULATION IN RESEARCH ON HUMAN COMMUNICATION

E. E. David, Jr., IRE, 1961

(Author's) SUMMARY - Same as (24.85)

(24.29)

MEASUREMENTS OF THE SUBJECTIVE EFFECTS OF INTERFERENCE IN TELEVISION RECEPTION

C. E. Dean, Proceedings of the IRE, June 1960

(Author's) SUMMARY

A measurement program was conducted in which almost 200 observers made about 38,000 rating observations on color and monochrome stationary television pictures impaired by various known amounts of interference. Separate tests were made for the following types of interference: upper adjacent channel, lower adjacent channel, random noise, co-channel with each of six carrier-frequency separations, and simultaneous random noise and co-channel. Six rating grades were used as follows: 1) Excellent, 2) Fine, 3) Passable, 4) Marginal, 5) Inferior, and 6) Unusable. The observations were handled on a statistical cumulative frequency basis and plotted on probability paper. Commercial monochrome and color receivers were used, and the tests were made with laboratory signal-generating equipment on the lower VHF television channels.

As representative results, a picture impaired by upper-adjacent-channel interference (with 6-mc channels) was rated by 50 per cent of the observers as Passable or better for -27db ratio of signal to interference. For the lower adjacent case a similar value was found, this result being explained as due to better traps in the medium-high-grade receivers of the test than in many receivers in use by the public. For random-noise interference the requirement for Passable or better rating by 50 per cent of the observers was +27 db on the basis of RMS sync amplitude to RMS noise over the 6-mc channel. The co-channel tests gave the following requirements for the Passable or better rating by 50 per cent of the observers: 22 db for 360 cycles offset, 41 db for 604, 24 db for 9985, 17 db for 10,010, 29 db for 19,995, and 17 db for 20,020. Data for simultaneous co-channel and random-noise interference were taken for 14 combinations of test conditions.

(24.83)

NARROW-BAND TV USES PSEUDO-RANDOM SCAN

Sid Deutsch, Polytechnic Inst. of Brooklyn, Electronics, April 1962

No ABSTRACT

(27.114)

THE POSSIBILITIES OF REDUCED TELEVISION BANDWIDTH

Sid Deutsch, IRE Transactions on Broadcast and Television Receivers, October 1956

(Author's) SUMMARY

A solution is sought to the following problem: Given a wide bandwidth of the order of 50 kc, devise standards such that the entertainment value shall be maximized. Four applications are considered: tape recording at a tape speed of 15 inches per second; telephone conversation accompaniment over high-quality telephone and long distance wire-line transmission over high quality telephone lines; and short-wave transmission over a 120 kc channel. Bandwidth reduction is achieved through reduced resolution, reduced field frequency, increased interlacing ratio, the use of dot interlace, and the use of quantizing and coding. The scanning frequencies and synchronizing signal are derived for each case. In addition, for the short-wave system, a method of combating multipath transmission is suggested.

(24.153)

ANALYSIS OF SOME REDUNDANCY REMOVAL BANDWIDTH COMPRESSION TECHNIQUES

L. Ehrman, Proceedings of the IEEE, Vol. 55, No. 3, March 1967

(Author's) ABSTRACT

Three redundancy removal bandwidth compression algorithms - the floating-aperture predictor, the zero-order interpolator, and the fan interpolator - are analyzed. Theoretical expressions are found for the mean and mean-square times between output samples of these devices when the input signal is a Markov process. These expressions are evaluated for the case in which the input is a first-order Gaussian Markov process, and the resulting output sampling rates and transmission bandwidths are compared to those required

(24.153) Continued

by a PCM system using uniform sampling and optimum linear filter interpolation. It is shown that, given sufficient a priori knowledge of the signal process, there is little to be gained by using these redundancy removal techniques in place of the PCM system. However, if the signal statistics are unknown, the use of these algorithms instead of PCM may provide a considerable bandwidth reduction.

(24.179)

THE RELATION OF NUMBER OF SCAN LINES PER SYMBOL HEIGHT TO RECOGNITION OF  
TELEVISED ALPHANUMERICS

M. F. Elias, A. M. Snadowsky, E. F. Rizy, Tech. Doc. Report No. RADG-TDR-64-433  
AD 608789

(Author's) ABSTRACT

To determine the effect of symbol resolution on the recognition of alphanumeric symbols displayed on a television screen (video tube), 10 subjects were repeatedly exposed to 36 symbols under 9 conditions of symbol resolution. Results indicated that, depending upon its unique configuration, a symbol will require a greater or fewer number of scan lines than another to be correctly identified; and, for most symbols, a resolution as low as three or four scan lines is not adequate for acceptable accuracy of identification under controlled laboratory conditions.

(24.172)

THE LUNAR ORBITER PHOTOGRAPHIC SYSTEM

B. L. Elle, SMPTE 101st Tech. Conference, April 16-21, 1967

(Author's) SUMMARY

The photographic system which produced the photographs of the lunar surface is a complex one. Inherent in its design is provision for dual lens photography, film processing, conversion of the film images into video signals for relay through the spacecraft transmitter, and reconstitution of the photographic image on earth after receipt of signals by the orbiter tracking stations. The prime objective of the Lunar Orbiter Mission is to secure topographic data

(24.172) Continued

of the lunar surface to enable selection and confirmation of suitable Apollo landing sites. In addition to the stringent performance objectives, the equipment design was strongly influenced by a number of constraints; e.g., size, weight, power consumption, pressure environment, the ambient thermal environment and the limitation on system control and instrumentation. Fundamental to the photographic system design was the selection of a suitable film processing chemistry and lenses. These are all reviewed in detail. The performance photographic requirements for the ground equipment are also briefly reviewed.

(24.107)

**DIGITAL TELEVISION - SHRINKING BULKY BANDWIDTHS**

**J. K. Fadely, J. M. Knight, G. L. Raga and B. C. King, Electronics, Vol. 37, December 1964**

(Author's) SUMMARY

Its flexibility and relative immunity to distortion have long been known. Now a new approach solves the bandwidth dilemma, providing an effective tool for command and control or extended space-probe observations.

(24.16)

**XV PROCESSING AND TRANSMISSION OF INFORMATION**

**R. M. Fano, et al, Quarterly Progress Report No. 70, July 1963**

**NO ABSTRACT**

(24.15)

**X PROCESSING AND TRANSMISSION OF INFORMATION**

**R. M. Fano, et al, Quarterly Progress Report No. 70, July 1963**

**NO ABSTRACT**

(24.42)

A MODEL FOR THE RANDOM VIDEO PROCESS

L. E. Franks, Bell System Technical Journal, April 1966

(Author's) SUMMARY

For problems concerning the transmission of video signals, it is often desirable to know the statistical distribution of power in the frequency domain for the signal process. It is convenient to have a model, involving only a few essential parameters, which will satisfactorily characterize the power spectral density of the random video signal. This paper proposes a model for the random picture and derives expressions for second-order statistical properties of the video signal obtained from a conventional scanning operation on the picture. The properties of typical picture material make valid certain approximations which lead to especially simple, closed-form expressions for power spectral density. The continuous part of the power spectral density is expressed as a product of three factors, characterizing separately the influence of point-to-point, line-to-line, and frame-to-frame correlation. For parameters representative of typical picture material there is observed an extreme concentration of power near multiples of the line scan and frame scan rates. An illustrative example of the use of the model in an optimum linear filtering problem is included.

(24.28)

PICTURE QUALITY - PROCEDURES FOR EVALUATING SUBJECTIVE EFFECTS OF INTERFERENCE

G. L. Fredendall, W. L. Behrend, Proceedings of the IRE, June 1960

(Author's) SUMMARY

In 1958, Panel 6 (Levels of Picture Quality) of the Television Allocations Study Organization conducted a comprehensive study of the subjective effects on picture quality of a number of types of interfering signals and noise, as functions of the levels of interference. These tests were designed and carried out by teams of engineers and experimental psychologists using a selective group of lay observers. This paper deals with the design of the tests and with the laboratory facilities used in the tests.

(24.88)

PICTURE QUALITY - PROCEDURES FOR EVALUATING SUBJECTIVE EFFECTS OF INTERFERENCE

G. L. Fredenall, and W. L. Behrend, Proceedings of the IRE, June 1960

(Same as 24.28)

(24.173)

DATA COMPRESSION WITH DIGITAL FILTERING

L. W. Gardenhire, Radiation, Inc., Telemetry Oct/Nov.1966

No Summary

(24.145)

OPTIMIZING SPACE TELEVISION TRANSMISSION

F.A. Gicca, International Telemetering Conf., Sept. 1963

(Author's) ABSTRACT

As space technology attempts to explore our planetary system in continually greater detail, the processing of data for minimum telemetry power is becoming increasingly important. In particular, television from space occupies extremely wide bandwidths and therefore demands high telemetry power. This paper explores how optimum digital television systems may be developed which require a minimum of spacecraft power and weight. Four digital television processing techniques are presented and their performance is compared with conventional analog television. The most promising of these approaches called "elastic encoding" provides telemetry power savings of about 5 db when compared to analog television.

(24.94)

DIGITAL SPACECRAFT TV CAN BEAT BIT-RATE AND WEIGHT PROBLEMS

F.A. Gicca, Space/Aeronautics/Electronics Dec. 1962

(Author's) SUMMARY

Four basic methods have been applied so far in attempts to solve the main problem of digital TV for spacecraft-the excessive bit rates required by the typical encoding level of six bits. This article reviews these methods in some detail, with particular emphasis on delta modulation and Roberts pseudo-noise modulation. It points out that, of all the bit-reduction techniques, elastic encoding looks most promising, and describes the design and operation of a "synthetic-highs" version of an elastic encoder. In this system, the output frame rate and therefore the transmitter power depend on the average information content of the transmitted pictures and not on that of the picture with the highest detail.

(24.152)

STUDY OF AN ADAPTIVE QUANTIZER

L.S. Golding and P.M. Schultheiss, Proceedings of the IEEE, Vol. 55, No. 3, March, 1967

(Author's) ABSTRACT

As adjustable uniform quantizer dependent on observation of blocks of quantized samples is investigated. In this quantizer, the range the samples are expected to occupy within a block is predicted from observation of the previous block. Then the upper and lower saturation levels of the quantizer are adjusted independently to correspond to this predicted range. This procedure is repeated for each new observed block of samples.

The adaptive quantizer is evaluated by means of a computer simulation, comparing it to a uniform quantizer with fixed saturation levels. The system is evaluated for television signals, spacecraft engineering sensor signals, and a multiple Gaussian Markov process. For the television signals, the adaptive quantizer acquires a "variable-range" mode of operation, making use of coherence between successive lines in a frame to achieve a reduction in error. When processing the other signals, the adaptive quantizer acquires a "fixed-range variable-mean" mode of operation achieving reductions in mean squared quantization error from 30 to 90 percent. A comparison with an ideal quantizer illustrates the ability of the adaptive quantizer to make effective use of coherence between samples to achieve a reduction in quantization error.

(25.54)

TELEVISION BY PULSE CODE MODULATION

W.M. Goodall, Bell System Tech. J. 30, 1951

(Author's) SUMMARY

Transmission by pulse code modulation presents inviting possibilities in the field of television in that information may be relayed by many repeater stations without deterioration. In a PCM system, the information signal is periodically sampled and its instantaneous amplitude described by a group of pulses according to a pre-set code. These pulse groups occur at the sampling rate and constitute the transmitted signal. In this process an operation known as amplitude quantization is required.

This paper will include a discussion of time sampling, amplitude quantization, binary coding and decoding of a television signal. The operation



of the equipment used to perform these functions is described.

The results obtained with an experimental system for different numbers of digits (i.e., maximum number of pulses per group) from one to five are illustrated by photographs. The television signal used in these tests was obtained from a special low noise film scanner. As was expected, the number of digits required depends upon the amount of noise in the test signal.

(24.76)

#### BANDWIDTH COMPRESSION OF A TELEVISION SIGNAL

G.G. Gouriet, Paper No. 2357R May 1957

#### (Author's) SUMMARY

Two sets of data are fundamentally required to describe a television picture, one giving the significant changes of brightness, and the other the positions of such changes. The total information content is calculated according to Shannon, and the means are discussed for reducing bandwidth by redistributing the data in time so as to achieve a constant rate of transmission. Maximum compression is achieved by treating the two sets of data as independent quantities, and using two channels for their transmission. A compromise may be adopted, however, in which almost the maximum bandwidth compression is achieved using a single channel at the cost of an increase of signal power.

The method is flexible in that it permits of an exchange to be made between the size of picture element and the continuity of grey scale, for a minimum stated bandwidth.

(24.144)

#### IMAGE TRANSMISSION BY TWO-DIMENSIONAL CONTOUR CODING

D.N. Graham, Proceedings of the IEEE, Vol. 55, No. 3, March 1967

#### (Author's) ABSTRACT

The results of a computer simulation of an image transmission system are reported. A reduction in the total number of bits required to describe a picture by a factor of 4 to 23 is possible as compared with 6-bit PCM. In this system an image is treated as a two-dimensional signal of the spatial coordinates x and y. The large changes in brightness in a picture occur

at the edges of objects and are accentuated by the visual system. The edge points can be isolated by the gradient or Laplacian operator. The fact that these edge points lie along connected contours in two dimensions is used to code the location and characteristics of each point efficiently. Two-dimensional reconstruction filters are derived to synthesize the high frequency picture from the decoded edge information. A two-dimensional low-pass or out-of-focus picture is also formed which can be transmitted with a relatively small number of bits. After a possible accentuation to make the picture appear "sharper," the "synthetic highs" signal is added to the low-pass picture to yield the final output.

(24.135)

## XII. COGNITIVE INFORMATION PROCESSING

D.N. Graham, Quarterly Progress Report No. 75, M.I.T. Research Lab. of Electronics, Oct. 1964.

NO ABSTRACT

(24.160)

## A HYBRID GRAPHICAL DISPLAY TECHNIQUE

H.L. Graham, Electronic Systems Laboratory, N66-39295, May 1966

(Author's) ABSTRACT

An on-line graphical display technique and an experimental system prototype employing this technique are discussed. Unlike some methods, which display graphical data by point-plotting or by piecewise-linear segments, this technique employs a sequence of curved segments. This approach results in compact storage of the digital commands that describe a complex curve at the expense of some computing time necessary to establish these commands.

The prototype system, which is based on this technique, is relatively uncomplicated and inexpensive; therefore, it is suited for use at the remote consoles of a time-shared computer facility.

(24.53)

COMMUNICATION THEORY APPLIED TO TELEVISION CODING

R.E. Graham, Bell Telephone Labs, Acta Electronics, 2, 1957-58

The problem of encoding a continuous television signal for efficient transmission over a digital channel is discussed. Two arbitrary categories of available techniques "time-warping" and "hyperquantizing" - are set forth, and some of their idiosyncrasies described. An experiment is described in which point-by-point prediction of a television picture is carried out by a human being, and the indicated channel saving by means of statistical coding is calculated from the prediction error statistics. Some drawbacks of straightforward prediction-error coding are pointed out, including the effects of random noise embedded in the signal prior to processing, and the disadvantages of conventional amplitude quantization as a prelude to coding. These limitations are to some extent avoided in an alternative approach to channel capacity economy through efficient numerical description of the original picture. Illustrations of such "hyperquantizing" methods include a combination of band splitting with conventional amplitude quantization, and a variant of differential quantizing. An experimental trial of differential quantizing of picture signals is described, in which an information transmission rate of three binary digits per picture sample is required. A number of examples of the resulting pictorial reproduction as shown.

(24.158)

ON THE NATURE OF INFORMATION-AN APPLICATION OF ENTROPY

M. Grossman, IEEE Spectrum Dec. 1965

NO ABSTRACT

(24.50)

READING AND WRITING WITH ELECTRONIC BEAMS

J. Herbert Jr., Electronics, 30 May 1966

NO ABSTRACT

(24.27)

A CYLINDRICAL CODING TUBE FOR 8-DIGIT CODE

H. Heynisch, Proceedings of the IEEE, Nov. 1963

(Author's) SUMMARY

The cylindrical coding tube discussed in this paper has been designed for converting a sampled analog signal into a digital signal of reflected binary (Gray) code. The physical principle of the tube is one of electron-optical image formation in a coaxially symmetrical electric field, similar to 45°-focusing in a homogeneous field. This principle leads to a minimum of image errors.

The voltages applied to the tube remain below 250 volts, the control voltage being smaller than 65 volts. The current pulses are decoupled on eight discrete collectors. The signal sampling frequency may go up to 10 Mc and higher.

The tube is relatively sturdy in its physical construction, the cathode being designed for a long life expectancy. The tube assembly is 65 mm in diameter, 250 mm long, and has a weight of less than 300 gms.

(24.170)

APPLICATION OF REDUNDANCY REDUCTION TO TELEVISION BANDWIDTH COMPRESSION

D. Hochman, H. Katzman, and D.R. Weber, Proceedings of the IEEE, Vol. 55, No. 3, March, 1967

(Author's) ABSTRACT

Redundancy reduction processes have proven highly effective in compressing the bandwidth of pictorial data. Compression is achieved by approximating the video time function with polynomial sequences.

This paper presents experimental results obtained by computer simulation, demonstrating the effectiveness of redundancy reduction when applied to different examples of pictorial material. Some of the practical considerations in implementing bandwidth compression systems for both black-and-white and color television are also discussed.

Based upon these simulation results and laboratory investigations, it is estimated that video bandwidth reductions from two to four can be accomplished with the present state-of-the-art.

(24.148)

DESIGN CONSIDERATIONS IN PCM TRANSMISSION OF LOW-RESOLUTION MONOCHROME  
STILL PICTURES

T.S. Huang, O.J. Tretiak, B. Prasada, and Y. Yamaguchi, Proceedings of the  
IEEE, Vol. 55, No. 3, March, 1967

(Author's) ABSTRACT

We present some results concerning the effects of changes in system parameters on the picture quality in PCM transmission systems. We restrict our attention to low-resolution monochrome still pictures, and discuss in particular the effects of the number of samples per frame, the number of brightness levels, the scanning pattern, and the channel noise, with a view to the optimal choice of these parameters.

(24.101)

DIGITAL PICTURE CODING

T.S. Huang, National Electronics 22nd Conference, Chicago, Illinois,  
Oct. 3-5, 1966, Proceedings.

NO ABSTRACT

(24.91)

PCM PICTURE TRANSMISSION

T.S. Huang, Research Laboratory of Electronics, MIT, IEEE Spectrum Dec. 1965

NO ABSTRACT

(24.115)

RESEARCH IN PICTURE PROCESSING

T.S. Huang and O.J. Tretiak, Symposium on Optical and Electro-optical  
Information Processing Technology, Boston, Mass., Nov. 9, 10, 1964,  
Proceedings.

NO ABSTRACT

(24.117)

DIGITAL PICTURE CODING

T.S. Huang, Mass. Institute of Technology, Cambridge, Mass.

NO ABSTRACT

(24.118)

USE OF SPACE VEHICLE TELEVISION DEVELOPMENTS FOR COMMERCIAL AND INDUSTRIAL USE

C.T. Huggins, Symposium on Technology Status & Trends, Huntsville, Alabama,  
April 21-23, 1965

(Author's) ABSTRACT

The application of a technique developed by MSFC for space vehicles for expanding the capacity of a transmission system is discussed as it could apply to commercial and industrial situations. A short history of the development and theory of operation is given using slides and film clips for illustration.

The system is basically a specialized method of time-sharing the output of a number of cameras to create an interleaved-information stream which can be sent over conventional television transmission links such as a long-line cable or microwave links. The composite stream of information is separated at the receiving terminal into a number of channels equal to the channels at the transmitting terminal. Each channel may be viewed on a monitor as though it were being transmitted continuously.

Uses of the capacity-expansion portion of the system is described as it is related to industrial and commercial applications. Examples of these are multipoint surveillance within two or more plants and multicamera coverage of sports or news events. Also briefly discussed are the new developments which compliment both the transmission and reception ends of the above system.

(24.26)

A UNITY BIT CODING METHOD BY NEGATIVE FEEDBACK

H. Inose and Y. Yasuda, Proceedings of the IEEE, Nov. 1963

(Author's) SUMMARY

Signal-to-noise performances of a unity bit coding method and the characteristics of an experimental video encoder based upon the principle are described. The system contains a signal integration process in addition to the original delta modulator and features capability of transmitting dc component of input signal.

The characteristics of the quantizing noise to the signal amplitude and the integrator time constant are obtained theoretically as well as experimentally. The characteristics of periodical noise which are inherent to the proposed system are also investigated.

The design and the characteristics of an experimental encoder for digital transmission of video signals are described as examples of the experimental equipment constructed to demonstrate the realizability of the principle. The experimental results show that considerably good reproduction of video pictures is obtained with sampling frequency as low as 30 Mc and suggest that the proposed system well fulfills the purpose.

(24.116)

DELTAMODULATION, A METHOD OF TRANSMISSION USING THE 1-UNIT CODE

F. de Jager, Philips Res. Rep. 7, 1952

(Author's) SUMMARY

It is known that in a communication system the influence of interferences in the transmission path can be reduced considerably by coding the information signal first and transmitting then a corresponding pulse pattern of 0 and 1 pulses. In wellknown systems of pulse-code modulation the n-digit binary code is used. In deltamodulation, however, a "code" comprising only 1 digit is used. Here the reproduced signal is obtained by applying the series of quantized pulses to a linear network. This system enables us to obtain a simplification of both coding and decoding devices. The conversion of the information signal into a quantized pulse pattern is achieved by using a negative-feedback circuit in which the voltage applied to the feedback network is quantized both in amplitude and in time. The network in the feedback loop should be related to the mean spectrum of the information signals. For speech an integrating network may be used as such. It is found, however, that the frequency characteristic

of the feedback network for frequencies lying between the highest speech-frequency and the pulse frequency has its influence on the amount of quantizing noise in the reproduced signal. A reduction of the quantizing noise is acquired by using a combination of single and double integration in this frequency region. Then the ratio between the r.m.s. values of the information signal and the quantizing noise is proportional to the  $5/2$  power of the pulse frequency.

(24.49)

PRINTING BY WIRE

W.P. Jaspert, Perspective, 1966

NO ABSTRACT

(24.134)

BANDWIDTH COMPRESSION TECHNIQUES FOR METEOROLOGICAL SATELLITE PICTURES

E. D. Jones, N66-19006, Stanford Research Inst., May 1965

(Author's) ABSTRACT

A selection of TIROS and Nimbus satellite cloud pictures were processed to reduce the bandwidth required for transmission. Several analog processing methods were studied, each aimed at a 9:1 bandwidth reduction ratio. A detailed technical description of the several processes is given, together with the cloud photographs that resulted. A possible implementation of a real-time operational system is included. A discussion of noise considerations, errors, analog logic techniques, and a comparison of the evolved bandwidth reduction system with other approaches is appended.

It is concluded that the bandwidth compression schemes described here retain meteorologically significant features decidedly better than a system based on simple low-pass spatial filtering (averaging).

(24.32)

PULSE-SWITCHING CIRCUITS USING MAGNETIC CORES

M. Karanugh, Proceedings of the IRE, May 1955

NO ABSTRACT



(24.68)

EXPERIMENTAL TRANSMITTING AND RECEIVING EQUIPMENT FOR HIGH-SPEED FACSIMILE  
TRANSMISSION V. SYNCHRONIZATION OF TRANSMITTER AND RECEIVER

D. Kleis and M. van Tol, Philips Techn. Review Vol. 10/No. 11, May 1949

(Author's) SUMMARY

The motors which bring about the scanning of the picture areas in the transmitter and in the receiver of the Philips apparatus for high-speed facsimile transmission have to run synchronously with a tolerance of no more than 0.6 degree in their relative phase. This requirement cannot be met with synchronous motors, nor with the system of stabilization by means of tuning-fork generators much used for low-speed facsimile transmission. A new method of synchronization had, therefore, to be developed. A regulating device was employed which reacts to phase deviations between the motors in the transmitter and the receiver, combined with a similar device reacting to differences between the speeds of the two motors. These devices are controlled by synchronizing pulses produced by the optical rotor in the transmitter and transmitted to the receiver together with the facsimile signal, and with the aid of pulses produced by a small generator coupled to the shaft of the receiver motor. Moreover, in the transmitter a device is used which stabilizes the speed of the transmitter motor, so that the synchronization only needs to provide a correction for small variations in the transmitter. With this method it has been possible to reach the necessary phase constancy; in the event of a disturbance the equilibrium is aperiodically restored, with such an inertia that the edge of the recorded picture does not show any disturbing undulation.

(24.64)

EXPERIMENTAL TRANSMITTING & RECEIVING EQUIPMENT FOR HIGH-SPEED FACSIMILE  
TRANSMISSION IV. TRANSMISSION OF THE SIGNALS

D. Kleis and M. van Tol, Philips Tech. Review, Vol. 10/No. 10, April 1949

(Author's) SUMMARY

The transmitting apparatus of a facsimile equipment supplies a voltage which varies in accordance with the blackness of the successively scanned image elements. This "facsimile signal" has a Fourier spectrum beginning at the frequency zero and extending, in the case of the Philips system for high-speed facsimile transmission, to 100 kc/s. In the transmission of the signal to the receiving apparatus, where it has to control a gas-discharge lamp which records the image on a film, there are particularly four stages of importance: amplifying, modulating, reversal and slicing. Modulation on a carrier wave is necessary because the carrier-telephone cables suitable for the transmission do not pass the lowest frequencies of the signal. A carrier of 100 kc/s is used, thus equal to the highest signal frequency; the lower side band is

transmitted. At the receiving end no demodulation in the ordinary sense of carrier-telephony is required, and a conventional full-wave rectifier will perform this function satisfactorily. The signal has to be amplified before it is modulated and in the receiver amplification again takes place in order to modulate an output valve supplying the recording lamp. Alternating voltage amplifiers are used, which, it is true, do not transmit the direct-voltage component of the signal (average blackness of the image, frequency "zero"), but the exact position of all signal levels can be reconstructed by the periodical transmission of impulses with a given level and the use of C-R coupling elements with an auxiliary diode. For this principle, known in television, an improved circuit has been applied in our system. A reversal stage permits the recording on the film to be made either positive or negative. The slicer can advantageously be so set that for black-and-white documents, for instance, parts with a reflection coefficient of 60% and more are recorded as white and those with a reflection coefficient of 40% or less as black.

(24.67)

EXPERIMENTAL TRANSMITTING AND RECEIVING EQUIPMENT FOR HIGH-SPEED FACSIMILE TRANSMISSION II. DETAILS OF THE TRANSMITTER

D. Kleis, F.C.W. Slooff and J.M. Unk, Philips Techn. Rev. Vol. 10/No. 9 Mar 1949

(Author's) ABSTRACT

In the transmitter of the high-speed facsimile transmission system developed by Philips the documents to be transmitted are held electrostatically on a conveyor belt by a D.C. voltage of several kV. A rotating optical system, around which the conveyor belt is curved perpendicular to its direction of movement, scans the paper in parallel lines at the rate of 180 lines per second. The rotor comprises three identical scanning units set at angles of  $120^\circ$  to each other, so that it is only necessary for the conveyor to curve through  $120^\circ$ . The three scanning systems in turn project a scanning spot  $1/5\text{mm}$  in diameter on the document to be scanned and at the same time concentrate the diffusely reflected light on a stationary secondary-emission photo-electric cell. A carefully designed optical system, using a film projection lamp as light-source, produces at the photo-electric cell a luminous flux of 0.20 for black and 0.70 millilumen for white parts of the document. As the signal supplied by the photo-electric when scanning white is 43 db above the noise level, the latter produces no visible fluctuations in the tone of the received image.

(24.131)

DATA COMPRESSION BY REDUNDANCY REDUCTION

C.M. Kortman, IEEE Spectrum March 1967

(Author's) ABSTRACT

Because of the increasingly pressing problem of spectrum overcrowding in data transmission channels, it is becoming more and more necessary to develop schemes to optimize the use of the available frequencies. The Proceedings of the IEEE is devoting its March issue to the subject of "Redundancy Reduction and Bandwidth Saving." This article, timed to coincide with the Proceedings issue, briefly describes some of the salient features of the various approaches to redundancy reduction.

(24.73)

REDUCED-ALPHABET REPRESENTATION OF TELEVISION SIGNALS

E.R. Kretzmer, Bell Telephone Laboratories, Inc., New Jersey

(Author's) SUMMARY

Experimental results are presented, in the form of kinescope photographs, showing the performance of a scheme for reducing the alphabet required for the discrete representation of television signals. The reduction is obtained by unusually coarse amplitude quantization of the high-frequency components of the signal, the low-frequency components being rendered with customary accuracy. The experiments reported on are of an exploratory nature and pertain to a system requiring about half as much channel capacity as that needed with conventional discrete representation. The resulting picture degradation is of an unusual nature and is surprisingly small for many types of picture material.

(24.41)

STATISTICS OF TELEVISION SIGNALS

E.R. Kretzmer, Bell System Technical Journal 31:751 (1952)

NO ABSTRACT

(24.25)

AUTOMATIC PICTURE DETAIL DETECTION IN THE PRESENCE OF RANDOM NOISE

M.H. Kubba, Proceedings of the IEEE, Nov. 1963

(Author's) SUMMARY

This paper is intended to be a companion to the paper in this issue by Cherry, et al., entitled "An Experimental Study of the Possible Bandwidth Compression of Visual Image Signals." It concerns particularly that part of the visual signal compression process carried out by the "picture detail detector". The purpose of this detector is to make a continuous running examination of a scanned video signal, in real time and to make successive decisions concerning the location of essential sample points. These points are the boundaries between successive step functions which adequately represent a reduced form of the picture suitable for encoding in a compression scheme. "Suitable" here means an adequate representation of the picture as judged by eye. The device is based upon a statistical inference process which effectively leads to discrimination between the video signal and the background random noise based upon the fact that the statistical properties of successive picture points are different for the picture itself and for the noise.

(24.63)

TIGHTENING THE BELT ON TV BANDWIDTH

G. Lapidus, New York

NO ABSTRACT

(24.176)

DISCRETING OF IMAGES BY SEPARATION AND QUANTIFICATION OF CONTOURS

D.G. Lebedev, D.S. Lebedev, N65-26186, NASA

(Author's) ABSTRACT

A means of discretizing of images (see note) which ensures a significant lowering of the required number of levels of quantification by comparison with the usual discretizing procedure is investigated. The procedure is based on separation and quantification of values of brightness of elements of the images which form curves with subsequent reproduction of smooth transition by two

dimensional interpolation. Selection of the Laplacian as the operator for separation of the contours is founded. Results of simulation of the proposed procedure for discretizing on an electronic digital computer are presented.

\*(noted): D.G. Lebedev, D. S. Lebedev, "A Procedure For Analysis and Synthesis of Television Images," authors copyright No. 163204 with priority from 5 July 1962.

(24.162)

APPLICATION OF PERCEPTRONS TO PHOTOINTERPRETATION

H.R. Leland, G.E. Richmond, M.G. Spooner, Report AD No. 603377, Aug. 1963

NO ABSTRACT

(24.139)

SOURCE-RECEIVER ENCODING OF TELEVISION SIGNALS

J.O. Limb, Proceedings of the IEEE, Vol. 55, No. 3, March 1967

(Author's) ABSTRACT

The first stage of efficiently coding television signals-the nonreversible process of obtaining a discrete signal-is investigated. The process depends on the properties of the source and the receiver which in this case is the human sense of vision. Emphasis is given to the examination of the properties of the receiver and the selection of an appropriate criterion of performance. The criterion adopted is the probabilistic measure of viewer preference in a direct comparative judgment between the original and the coded-decoded version. For this criterion the precision with which picture components need be reproduced will depend primarily on the visual thresholds associated with the picture components. The "Optimum Decision" model of threshold vision is investigated using the criterion.

As an example a practical encoder is discussed which is designed around the loss of sensitivity of the visual system adjacent to a change in luminance. High-quality pictures have been encoded having first-order entropies in the range 0.8 to 2.0 bits per picture element.

(24.105)

IMPROVEMENTS TO BE REALIZED THROUGH THE USE OF BLOCK-CODED COMMUNICATION SYSTEMS

W.C. Lindsey, C.I.T. Jet Propulsion Lab., IEEE Transactions on Aerospace and Electronic Systems, Vol. AES-2, May 1966.

NO ABSTRACT

(24.161)

THEORETICAL AND EXPERIMENTAL PROCESSING OF LUNAR TELEVISION PICTURES

C.S. Lorens, A.M. Boehmer, J. Gallagher, N65-17214 11/2/62

(Author's) ABSTRACT

It is estimated that large quantities of lunar planetary pictures are to be obtained from forthcoming experiments. The processing of pictures through digital computer techniques offers one possibility for handling the large number of pictures which are to result from these experiments. This report is the final report on a theoretical and experimental study of techniques for processing pictures.

An outline is presented of possible linear and non-linear theoretical work which can be made applicable to processing lunar and planetary pictures. The theoretical material of this report is limited to linear processing. The material deals with exploiting the geometry of pictures principally through the assumption of statistically stationary properties under translation and rotation. Pictures are defined as functions of one index where the index is a 2-dimensional vector corresponding to the 2-dimensional coordinates of the picture. This notation makes it possible to handle pictures in the conventional 1-dimensional notation of classical processing theory while preserving the 2-dimensional properties of the picture. The report deals with representation of the pictures, linear processing, matrix products, correlation functions, stationary and symmetry properties optimum linear processing, trivial processing, orthogonal preprocessing, minimum error, minimization with a constant, preprocessing with prediction, quantization, and convergence of iterative computations.

The experimental work of this report tests the theoretical results for complexity, usefulness, and correctness. An experimental capability was developed capable of producing pictures with up to 750 elements in 6 shades of brightness corresponding to the 6 faces of the cube onto which the shades of brightness were pasted. This capability was then used in the experimental representation of the Craters Eratosthenes and Archimedes in 15 x 19 fields of elements. Artificial pictures were also constructed having controlled correlation functions. A number

of experiments were performed with these pictures to extract in an optimum manner another desired picture. A variety of FORTRAN programs are included for eventually performing the processing computations on a digital computer.

(24.98)

DIGITAL PULSE COMPRESSION USING POLYPHASE CODES

E. S. Lurin, IEEE Proceedings, Vol. 51, Sept. 1963.

NO ABSTRACT

(24.166)

NIMBUS DATA-HANDLING SYSTEM

R.M. Madvig, M.G.H. Ligda, A. Macovski, J.J. Bialik, A.R. Tobey, N 63 12010  
Oct. 1962

(Author's) ABSTRACT

This report covers the technical progress made during the third quarter of the project.

Some conclusions are made regarding requirements for distribution and processing of cloud pictures. The possible applications of infrared data and possible ways to automatically process the IR data are discussed. Operational applications of Nimbus data as obtained from a survey of weather analysis centers and weather forecasting groups are reported.

A method for rectification of cloud pictures is described, the problems associated with digital rectification are discussed, and the increase of communications cost for transmission of rectified pictures over the cost of transmission of unrectified pictures is reported.

The line-leasing costs are estimated for several networks for distributing cloud pictures to United States Weather Bureau agencies.

Methods for gridding and rectifying Nimbus cloud pictures on board the satellite are described.

A number of short topics on the subject of computer gridding are included in an appendix.

(24.39)

#### ULTIMATE SENSITIVITY OF IMAGING DEVICES

L.R. Malling, JPL Space Programs Summary No. 37-33 Vol. 4, 1965

##### (Author's) SUMMARY

The photon population for a given luminous intensity has been estimated by means of two separate concepts of the lumen. A useful approximation for space science is  $1 \text{ ft-c} = 1.1 \times 10^{16}$  photons/sec.

From the photon concentration on the picture element, the ultimate sensitivity may be expressed by quite simple equations: for non-storage devices as  $S/N = (n_a/B)^{1/2}$ , and for storage devices as  $S/N = (2n_a)^{1/2}$ .

The quantum efficiency of the slow-scan vidicon,  $\eta = 40\%$ , is seen to be much greater than is generally supposed and approaches that of the best photoconductive cells. As with the broadcast vidicon, early experimental samples exhibited a sensitivity that later units could only marginally exceed because of the fundamental relationship  $\eta = \tau/\tau_r$ , established by the camera system restraints.

(24.92)

#### DELTA MODULATION

Robert H. Maschhoff, Argonne Nat'l Lab., Electro-Technology, Jan 1964

##### (Author's) SUMMARY

Delta modulation has proved useful in some speech and video communication systems, and in control systems which require encoding and transmission of analog information. Use of delta modulation requires an understanding of its basic mode of operation and performance characteristics, and of its relationship to other, similar modulation methods.

(24.112)

#### VISUAL DATA TRANSMISSION

R.J. Massa, Data Sciences Lab. Project 4610, Air Force Cambridge Research Labs.

##### (Author's) ABSTRACT

Statistical coding and visual fidelity criterion approaches to the television bandwidth reduction problem are described and contrasted. A review of techniques based on both approaches is presented. A brief discussion of television signal properties and several television user applications is included. Emphasis is placed on bandwidth and/or power reduction through consideration and utilization of human visual summation properties. A class of reduced rate systems with random-scanning, non-information bearing masks, and amplitude weighting are presented and discussed.



(24.167)

APPLICATIONS OF COMPUTER GRAPHICS IN THE AEROSPACE INDUSTRY

D.M. Meadows, IEEE Reg. III Conv. Proc. April 1966

(Author's) SUMMARY

A description is given of the Lockheed-Georgia Company activities in the area of man-machine graphical communications. The Company program, Man-Computer Graphics (MCG), is discussed in terms of applications, software and hardware. A general background of the program is also provided.

(24.5)

PERCEPTION OF TELEVISION RANDOM NOISE

Pierre Mertz, Journal of the SMPTE, Vol. 54, Jan, 1950

(Author's) SUMMARY

The perception of random noise in television has been clarified by studying its analogy to graininess in photography. In a television image the individual random noise grains are assumed analogous to photographic grains. Effective random noise power is obtained by cumulating and weighting actual noise powers over the video frequencies with a weighting function diminishing from unity toward increasing frequencies. These check reasonably well with preliminary experiments. The paper includes an analysis of the effect of changing the tone rendering and contrast of the television image.

(24.12)

VIDICON APPLICATIONS FOR SPACE-BORNE TV CAMERAS

M.H. Mesner, SPIE Journal Vol. 3, 1965

(Author's) ABSTRACT

The feasibility of TV in satellites and space probes has been demonstrated in 8 TIROS vehicles. Other usages are discussed including other weather observational satellites, space astronomy for stellar and solar measurements, uses in manned and unmanned lunar missions, and biological observations. Solutions to problems pertaining to the space environment and the design choices in using vidicons for remote instrumentation are discussed. The direction of anticipated growth and development are outlined.

(24.48)

THE SURVEYOR LUNAR LANDING TELEVISION SYSTEM

D.R. Montgomery and F.J. Wolf, IEEE Spectrum, Aug 1966

(Author's) ABSTRACT

From the period of June 1, 1966, through June 14, and from July 6 through July 13, the Surveyor spacecraft television camera provided the United States a close-up view of the lunar surface at the millimeter scale. This article describes the functional engineering aspects of the camera and its performance capabilities.

(24.1)

PERFORMANCE EVALUATION OF IMAGE INTENSIFIER TELEVISION SYSTEMS

R.D. Moseley, T. Holm and I.H. Low, J. Roentgenol 92, Aug. 1964

(Author's) SUMMARY

Methods for the performance evaluation of image intensifier-television systems utilizing a modulation transfer function derived from the composite video signal have been described. The results with a stationary square wave test pattern and with a moving sine wave test pattern have been presented. The method is effective for the qualitative and quantitative evaluation of different systems, as well as for the developmental analysis of a single system. The technique may also be used to maintain a system at optimum performance levels.

(24.58)

TRANSDUCING SYSTEM FOR PHOTOGRAPHICALLY RECORDING VIDEO IMAGES AND SOUND SIGNALS RELATED THERETO

J.T. Mullin, June 15, 1965 (U.S. Patent No. 3,189,683)

NO ABSTRACT

(24.47)

DIGITAL VIDEO-DATA HANDLING

R. Nathan, Technical Report No. 32-877, Jet Propulsion Lab , Jan 1966

(Author's) ABSTRACT

A technique has been developed which makes it possible to perform accurate, detailed operations and analyses upon digitized pictorial data. Television pictures transmitted from the Ranger and Mariner spacecraft have been significantly improved in clarity by correcting those system distortions which affect photometric, geometric, and frequency fidelity. Various classes of structured noise have also been detected and removed digitally by means of newly devised two-dimensional filters. Although mathematically the filters are easier to describe in the frequency domain, they are more effectively applied as a convolution operation on the original digitized photographs. The cleaned-up, enhanced pictures are then used by the computer for further interpretive and statistical analyses.

(24.165)

AN EXPERIMENTAL FACILITY FOR SEQUENTIAL DECODING

C.W. Niessen, MIT N 66 28513 Tech. Report 450 Sept 13, 1965

(Author's) ABSTRACT

Sequential decoding is one of the few practical methods known for communicating over a noisy channel which, for interesting rates, attains the error-correction capability predicted by Shannon's coding theorem. Since analytical investigations are limited by the difficulty of the mathematics involved, experimental studies into the behavior of sequential decoding are necessary. This report describes the system design and implementation of a facility for the experimental study of sequential decoding that may be used at M.I.T. by graduate researchers in communications theory. Flexibility and ease of use are the primary requirements of this system.

Thorough investigation of the characteristics of sequential decoding and likely problems to be studied led to a system based upon the Project MAC PDP-6 computer. The design reflects constraints imposed by time, cost, equipment availability, and the anticipated class of users. A portable data-acquisition system, consisting of a digital tape recorder and analog-to-digital conversion equipment, is provided to make available to the computer the outputs of experimental demodulation equipment. The experimenter can decode the acquired data sequentially in accordance with an algorithm specified and easily written by him in a version of Fortran modified for this purpose. The modified Fortran contains statements for the use of special subroutines provided, such as a convolutional coder. The program is run within a monitor system which handles most input-output automatically and provides for man-machine interaction with the program. The monitor also collects statistics on the decoding process to aid the user in evaluating his algorithm.

All sequential decoding algorithms may ultimately be described as tree search algorithms in which it is desired to find the "best" path through a tree. A display of the paths searched by the algorithm has therefore been made the principal tool for the man-machine interaction. The user watches this display and controls the running of the algorithm via a light pen and commands typed to the monitor.

The system has been successfully implemented and tested, and experimental results are described.

(24.45)

#### AREA PROPERTIES OF TELEVISION PICTURES

S. Nishikawa, R.J. Massa, and Mott-Smith, IEEE Trans. on Information Theory  
IT-11 No. 3 July 1965

NO ABSTRACT

(24.164)

#### THE NIMBUS I METEOROLOGICAL SATELLITE-GEOPHYSICAL OBSERVATIONS FROM A NEW PERSPECTIVE

W. Nordberg, N65-29819, May, 1965

(Author's) SUMMARY

The Nimbus I meteorological satellite which was launched into a nearly polar, sunsynchronous orbit and was fully earth oriented carried a set of very high resolution television cameras, a directly transmitting television camera of lesser resolution and a High Resolution Infrared Radiometer. The observations of detailed cloud features during daytime, the direct transmission of such observations to local weather station via an Automatic Picture Transmission system and the measurement and pictorial presentation of earth, water and cloud temperatures from orbital altitudes at nighttime with the infrared radiometer have provided geophysical and meteorological measurements from a truly global perspective. Temperatures of ice surfaces of Antarctica and Greenland were presented in high resolution, radiation pictures with accuracies of about  $\pm 2^\circ\text{K}$ . Pictorial maps of cloud cover and of cloud top heights were obtained during nighttime permitting a three-dimensional analysis of the global cloud structure and inferences regarding the dynamics of weather fronts, severe storms, atmospheric circulation cells, etc. Measurements of sea surface temperatures were made in many areas of the world. Radiation patterns

observed over terrain in cloudless conditions indicate the temperatures of the soil and permit inferences, in certain cases, of soil conditions such as moisture, vegetation, mineral composition, etc. The data are available for further analysis by the scientific community and a catalog of all NIMBUS observations is contained in reference (9).

(24.125)

COMPUTER SIMULATION OF VISUAL DATA PROCESSING IN THE HUMAN BRAIN

D.L. Ockerman AD 619394 June 1965

(Author's) ABSTRACT

The operation of the visual portion of the human brain has been simulated on the IBM-1620 and IBM-7094 digital computers. The simulation is designed using the cross-correlation method postulated by Dr. Kabrisky. The simulation is very coarse as the grain size of the visual area of the human brain is four hundred times finer than the computer model. The model stores new patterns, standardizes pattern sizes, rotates the input pattern and recognizes identical or similar patterns. The model is evaluated by inserting twenty test patterns. The model did seem to simulate the human visual recognition system for these input patterns. The model will recognize patterns that are reduced, enlarged, shifted, or rotated. After analyzing the satisfactory results recommendations are made for the design of larger and more intricate models. The computer programs and sample results are included in the Appendixes.

(24.147)

A BOUND ON SIGNAL-TO-QUANTIZING NOISE RATIOS FOR DIGITAL ENCODING SYSTEMS

J.B. O'Neal, Jr., Proceedings of the IEEE, Vol. 55, No. 3, March 1967

(Author's) ABSTRACT

When an analog signal is encoded into digital form and then decoded back into an analog signal, quantizing noise is always introduced. The amount of quantizing noise which contaminates the decoded analog signal is inextricably tied to the amount of redundancy present in the signal and in the digital bit stream. Reducing the quantizing noise and, therefore, increasing the fidelity of the resulting signal requires that the redundancy in the digital bit stream be reduced or eliminated. There is a point, however, beyond which the quantizing noise cannot be further reduced. This is discussed in quantitative terms by deriving an upper bound on the signal-to-quantizing noise power ratio possible for a given bit rate and signal ensemble. Ratios of signal-to-quantizing noise greater than this bound are not possible for digital encoding systems. This bound is compared with the operation of pulse code modulation, differential pulse code modulation, and delta modulation systems.

(24.19)

SELECTED TOPICS IN OPTICS AND COMMUNICATION THEORY

Ed. O'Neill, Itek Corp., Sept. 1958

NO ABSTRACT

(24.138)

XIV. PROCESSING AND TRANSMISSION OF INFORMATION

J.W. Pan, Quarterly Progress Report , M.I.T. Research Lab of Electronics,  
July 1962

NO ABSTRACT

(24.141)

A REALISTIC MODEL FOR VISUAL COMMUNICATION SYSTEMS

D.E. Pearson, Proceedings of the IEEE, Vol. 55, No. 3, March 1967

(Author's) ABSTRACT

In this paper Shannon's model of a communication system is extended to allow for the influence of the human viewer on the encoding and decoding processes. The extended model is shown to represent actual visual systems more realistically and to lead to the design of viewer-oriented codes which maximize the fidelity of transmission. Systematic procedures for the calculation of these codes are suggested, with practical examples.

(24.109)

SEQUENTIAL OPERATIONS IN DIGITAL PICTURE PROCESSING

J.L. Pfaltz, A. Rosenfeld, Journal of the Association for Computing Machinery,  
Vol. 13, Oct. 1966

(Author's) ABSTRACT

The relative merits of performing local operations on a digitized picture in parallel or sequentially are discussed. Sequential local operations are described which label the connected components of a given subset of the picture and compute a "distance" from every picture element to the subset. In terms of the "distance" function, a "skeleton" subset is defined which, in a certain sense, minimally determines the original subset. Some applications of the connected component and distance functions are also presented.

(24.7)

AN EXPERIMENTAL PHOTO-TAPE FRAME-CAMERA SYSTEM

W. J. Poch, Journal of SMPTE 74: January 1965

(Author's) SUMMARY

The basic principles and advantages of recording and storing optical images in the form of equivalent electrical charge patterns on a special kind of flexible tape are presented. An experimental model of a frame-type camera system which was designed to demonstrate the feasibility of this method of recording is described. Characteristics of the camera and its method of operation are discussed. The paper describes the "prepare" or "erase" process, the "writing" or recording process and the "readout" process. The results of preliminary tests which are reported verify the validity of the basic concepts involved in this kind of video recording system.

(24.95)

SOME POSSIBILITIES OF PICTURE SIGNAL BANDWIDTH COMPRESSION

Birendra Prasada, IEEE Transactions on Communications Systems, Sept 1963

(Author's) SUMMARY

An experimental appraisal of the Cherry-Gouriet proposals, for the bandwidth compression of television signals by variable-velocity coding, has been made. A flying-spot variable velocity scanner was built for this purpose. The encoding of the signal in this system is done by a nonlinear feedback loop. Qualitative studies on the stability of the loop have been made. It has been found that the effect of the source noise on the encoder performance is extremely important. It is concluded that owing to the limitations of the devices, the variable-velocity scanner is not practically feasible for television transmissions. However, this system seems ideally suited for LF transmission of pictures.

The potential bandwidth compression of the B.B.C. test card C has been determined from its run-length statistics.

An open-loop system of bandwidth compression has been described which uses variable-rate sampling. Using the statistics obtained from the test card C, the storage requirement of the open-loop system has been assessed.

(24.171)

STOP-SCAN EDGE DETECTION SYSTEMS OF TELEVISION BANDWIDTH REDUCTION

W. K. Pratt, AD 465106, June 1965

(Author's) ABSTRACT

A family of systems is developed to code television pictures such that the bandwidth, or time, required for transmission is reduced significantly compared to transmission by conventional pulse code modulation. The systems have application for spacecraft television communication where the reduced bandwidth enables a reduction in transmitted power. Data from optical detection and tracking sensors may be processed at a significantly increased rate with the systems. Also, for a fixed communications bandwidth, the television bandwidth reduction systems permit an increase in the number of television channels that can be relayed by an earth orbiting satellite or microwave relay station.



(24.171) Continued

The major informational content of a television picture as judged by a human viewer lies in its outline, or edges, which occupy only a small area of the total picture. A bandwidth reduction is realized by transmitting video information suitably coded and time redistributed only at the edge positions in a picture. Edges are formed by subtracting the intensities of adjacent picture elements along a television line. If the difference signal exceeds a threshold value an edge exists. The position of each edge is coded as the number of elements scanned since the previous edge occurrence.

The time redistribution is performed by a stop-scan picture information gathering and display process at the coder and decoder eliminating the need for high speed buffer storage units. In the stop-scan process, camera scanning proceeds at a uniform rate; when an edge is detected, scanning is halted. At the next allowable edge transmission time, the video information is transmitted, and scanning resumes. The display of video information at the decoder follows an inverse stop-scan process.

In this report the psychophysical properties of image viewing related to television systems are investigated to determine the relationship between television design parameters and communications bandwidth. Information theoretic bounds of bandwidth reduction and the optimum selection of system parameters are established. Statistical image measurements are performed to determine the probability of occurrence of edges. The implementation of an operational prototype of the basic stop-scan edge detection system is described. Viewing tests are performed to verify the quality of pictures processed by the basic system.

(24.157)

#### MAN-COMPUTER GRAPHICS FOR COMPUTER-AIDED DESIGN

M. David Prince, Proceedings of the IEEE, Vol. 54, No. 12, December 1966

(Author's) ABSTRACT

This paper reviews the history, concepts, state-of-the-art, and future directions of the use of man-computer graphics for computer-aided design. Computer-aided design is based on a real-time graphical dialogue between the man and the computer in which the man draws on a display by means of a "light-pen" or other input device. The computer "understands" the picture, makes calculations based on it, and presents the results pictorially to the user for his approval or revision. This man-computer graphical conversation has been made possible by recent advances in the speed of the digital computer, time-sharing programming, computer-driven display technology, and graphical input

(24.157) Continued

devices. The light pen is the most commonly used graphical input device, but keyboards, joysticks, flat matrix arrays, and other devices are also used.

The programming state-of-the-art is a limiting factor in the implementation of graphical computer-aided design; much work remains to be done in systems programming, efficient time sharing, list structure concepts, file organization, and memory protection. A number of experimental equipment configurations in use in various laboratories are cited and the hardware state-of-the-art is reviewed.

Several experimental and production applications of computer-aided design evolved in a large aircraft company are described and illustrated by display photographs. These applications relate to structural analysis, dynamics, information retrieval, accounting, and numerical control tape preparation.

For the future, advances are required in improved man-computer communication, techniques to permit the operation of displays at great distances from the central computer, and methods of inputting existing drawings into the computer in a meaningful form.

(24.103)

#### THE UTILIZATION OF BANDWIDTH TO MINIMIZE REQUIRED TRANSMITTER POWER

G. Rabow, IEEE Transactions on Communication Technology, Vol. Com-13, June 1965

#### (Author's) ABSTRACT

In the transmission of a signal between two points, a set of primary parameters is the ratio  $2B$  of transmission bandwidth to signal bandwidth, the required signal-to-noise ratio  $P_0$ , the ratio  $P_c$  of transmitted power-to-noise density, and some measure of system complexity. The constraint here imposed on system complexity is not to allow coding in the time domain beyond that which is incidental to expanding the base signal bandwidth.

Typically, the original signal is first quantized into  $M$  levels where  $M = \sqrt{2P_0 + 1}$ . The  $M$ -ary digits are then transformed, into  $M'$  ary digits, where  $M'/\log M' = 4B/\log M$ . This is done to have the transmitted signal just fill the available transmission bandwidth. Transmission space is divided into  $M'$  bi-orthogonal components, such as two quadrature channels in each of  $M'/4$  noninterfering frequency channels. The  $M'$  integer then transmitted is a pulse in the appropriate one of the  $M'$  phase-frequency channels, and is detected by a maximum likelihood device. The resulting coding scheme reduces to conventional modulation methods such as AM, FM, PM, and PCM for certain combinations of  $P_0$  and  $B$ , but for all other cases requires lower  $P_c$ .

B49/B50

(24.169)

SIGNAL CODING FOR TRANSMISSION AND RESOLUTION USING GRAPH THEORETIC METHODS

C. V. Ramamoorthy, Honeywell, Inc. IEEE Annual Communications Convention, Boulder, Colo. June 1965

(Author's) ABSTRACT

The purpose of this paper is to develop a graph-theoretic approach to noiseless digital waveform coding for better signal resolution. The advantage of such an approach is that it provides an efficient representation of the discrete signal waveforms, an enumeration technique to count the maximum number of waveforms possible under a given set of constraints and measures of comparison between different encodings.

This paper is divided into two parts. The first part deals with signal representation and enumeration. In the second part we postulate codes suitable for signal resolution under noise jitter and inter-symbol interference. An example of implementation of the techniques in the case of an ultrasonic delay line is given.

(24.43)

DISTRIBUTION OF LIGHT PULSE SIZES FROM SINGLE CATHODE ELECTRONS IN AN IMAGE INTENSIFIER

G. T. Reynolds, D. P. Hutchinson and P. Botos, Jr., Brit. J. Appl. Physics, Vol. 17, 1966

(Author's) ABSTRACT

The size distribution of light pulses from the anode of a transmission secondary electron image intensifier tube has been measured for single photoelectrons emitted from the cathode. The distribution deviates from a simple exponential, but does not approach a Poisson distribution. The noise distribution has also been studied and several different components distinguished. The effect on these components of cooling the cathode has been investigated. By virtue of absolute calibrations, a measurement of the photon gain of the intensifier can be calculated from the observed single electron pulse height distribution. A comparison of this gain with that determined by a direct measurement indicates that a significant fraction of the electrons emitted from the cathode are lost in the dynode structure, even under conditions of good electron optics.

(24.44)

SENSITIVITY OF AN IMAGE INTENSIFIER FILM SYSTEM

George T. Reynolds, Applied Optics, Vol. 5, April 1966

(Author's) ABSTRACT

Using calibrated light sources, the sensitivities of several commonly used films have been determined in terms of the number of photons incident required to develop one grain of emulsion. By incorporating an image intensifier in the system, the time required to obtain an image of a given quality or information content can be reduced significantly. Criteria are discussed whereby an estimate of the time advantage can be made for various experimental conditions. Noise, quantum fluctuations, spatial resolution, and over-all detection efficiency are discussed.

(24.34)

FACSIMILE IMAGING SYSTEMS, PARTS I, II, III

G. H. Ridings, Western Union Technical Review, Vol. 18, No. 4, October 1964

NO ABSTRACT

(24.66)

EXPERIMENTAL TRANSMITTING AND RECEIVING EQUIPMENT FOR HIGH-SPEED FACSIMILE TRANSMISSION - I GENERAL

H. Rinia, D. Kleis and M. van Tol, Philips Technical Review, Vol. 10, January 1949

(Author's) ABSTRACT

In recent years a new system has been developed at Eindhoven for facsimile transmission and reception of drawings, photographs or printed matter capable of transmitting a document of quarto size (21 cm x 29.7 cm) in 8 seconds by means of a cable or by radio. The system is continuous: the documents, the size of which - apart from a limit on the width of 22 cm - is immaterial, are placed on an endless belt upon which they are electrically "stuck" for scanning by a rapidly rotating optical system. At the receiving end positive or negative reproductions, reduced 6 x in size, are "written" on a continuously moving film which then passes through the developing and fixing processes and can if necessary be printed immediately on sensitized

(24.66) Continued

paper, enlarged to the original size. The resolving power of the system is 5 lines per mm, which corresponds to the best reproduction obtainable from the older and slower types of equipment. A number of characteristic features and possibilities of application of the new system are reviewed in this article; a description of the mechanism, with details of the optical and electrical devices, will be presented in subsequent articles in this review.

(24.97)

PICTURE CODING USING PSEUDO-RANDOM NOISE

Lawrence Gilman Roberts, IRE *Transactions on Information Theory*, February 1962

(Author's) SUMMARY

In order to transmit television pictures over a digital channel, it is necessary to send a binary code which represents the intensity level at each point in the picture. For good picture quality using standard PCM transmission, at least six bits are required at each sample point, since the eye is very sensitive to the small intensity steps introduced by quantization. However, by simply adding some noise to the signal before it is quantized and subtracting the same noise at the receiver, the quantization steps can be broken up and the source rate reduced to three bits per sample. Pseudo-random number generators can be synchronized at the transmitter and receiver to provide the identical "noise" which makes the process possible. Thus, with the addition of only a small amount of equipment, the efficiency of a PCM channel can be doubled.

(24.99)

CODED DIGITAL COMMUNICATIONS - INFORMATION TRANSFER, NOT ENERGY TRANSFER

P. Rosen and I. L. Lebow, *Space Aeronautics*, Vol. 39, February 1963

(Author's) ABSTRACT

We know enough today about the application of communications theory and about digital coding, this article points out, to design communications systems on the basis of information transfer rather than energy transfer. The authors discuss what this approach involves in terms of the relationship be-

(24.99) Continued

tween data rate, channel capacity, and probability of error, and show how it affects the functional organization of transmitting and receiving terminals. The problems of substituting a discrete for a continuous channel and the suitability of various types of coding are also reviewed.

(24.174)

A PRECISION FLYING SPOT FILM DIGITIZER

Jerome A. G. Russell, N64-17291

NO ABSTRACT

(24.23)

CONSTRUCTION AND PERFORMANCE OF AN ELF DISPLAY SYSTEM

E. A. Sack, P. N. Wolfe, and J. A. Asars, Proceedings of the IRE, April 1962

NO ABSTRACT

(24.46)

A LOOK AT COMMERCIALY AVAILABLE LIGHT SENSITIVE IMAGING TUBES

I. T. Saldi, E. T. Chace, G. W. Iler, and H. Shabanowitz, Electronic Industries, May 1966

NO ABSTRACT

(24.113)

DELTA MODULATION, A NEW MODULATION SYSTEM FOR TELECOMMUNICATION

J. F. Schouten, F. de Jager, and J. A. Greefkes, Philips Technical Review, Vol. 13, No. 9, March 1952

(Author's) SUMMARY

In this article the development of different modulation systems is described, a development which aims at achieving the transmission of audio or video signals as free as possible from interference. The interference occurring in carrier modulation systems and also in pulse-position modulation arises from very small effects of interference being cumulative in the course of transmission. This cumulation can be eliminated by quantizing the signals to be transmitted, both in time and in amplitude. The system of delta modulation, based on this principle, is described and compared with other systems employing quantization (pulse code modulation). It appears that for a good reproduction, using a reasonable bandwidth for the transmitted signal, the apparatus required for delta modulation is relatively very simple, because of coding being applied with the aid of only one unit. This is possible by reason of the fact that with delta modulation account is taken of the correlation properties of the signal, by employing a special kind of inverse feedback in the transmitter, and that the properties of the system are matched with those of speech and music and of the human ear.

(24.77)

SYNTHETIC HIGHS - AN EXPERIMENTAL TV BANDWIDTH REDUCTION SYSTEM

W. F. Schreiber, C. F. Knapp and N. D. Kay, Journal of the SMPTE, Vol. 68, August 1959

(Author's) SUMMARY

A complete system is described which codes a standard video signal to match a narrower band channel and subsequently decodes the received signal for display on a standard TV monitor. The system transmits the low-frequency, or macrocontrast signal, in analog form. The location and amplitude of the edges are transmitted by a digital code. At the receiver the edge information is used to synthesize the highs content of the video, which is then added to the lows to reconstruct the original video signal. Bandwidth reduction is achieved by exploiting both statistical correlations and psychophysical phenomena.

Apparatus for the separation of low frequencies, detection of edges, quantization and binary digital coding of edge amplitude and synthetic reconstruction of highs is described. The digital coder for edge locations has been described elsewhere.<sup>1</sup> Picture-tube photographs of the resulting pictures are shown. Factors affecting the degree of bandwidth reduction and the effect of variation of system parameters such as separation frequency and quantization levels are discussed.

(24.149)

**PICTURE CODING**

W. F. Schreiber, Proceedings of the **IEEE**, Vol. 55, No. 3, March 1967

(Author's) **ABSTRACT**

A critical view is presented of the development of certain picture coding systems. An attempt is made to unify the treatment of these systems by emphasizing the reaction of the observer to the types of alteration introduced into the transmitted signal, on the basis of what is known about vision. For the purpose of casting a number of apparently different techniques into similar forms, the relationship between differential quantizing and PCM is discussed in detail. We conclude that the pre- and post-quantizing filters play a key role in these systems. Optimum choice of such filters is shown to improve both quality and efficiency. Two-dimensional and dual-mode systems are seen to be outgrowths of these considerations. Recent results are described and a method of comparison between systems is proposed.

(24.137)

**XVIII. PROCESSING AND TRANSMISSION OF INFORMATION**

W. F. Schreiber, Quarterly Progress Report No. 68, M.I.T. Research Lab of Electronics, January 1963

**NO ABSTRACT**

(24.90)

**INFORMATION TRANSMISSION, MODULATION, AND NOISE**

Schwartz

Comparative Analysis of Systems Chapter 6

**NO ABSTRACT**



(24.136)

XVII - COGNITIVE INFORMATION PROCESSING

F. U. Scoville, Quarterly Progress Report No. 78, M. I. T. Research Lab of Electronics, July 1965

NO ABSTRACT

(24.177)

A STUDY OF FACTORS INFLUENCING THE LEGIBILITY OF TELEVISED CHARACTERS

W. F. Seibert, D. F. Kasten and J. R. Potter, Journal of the SMPTE, Vol. 68 July 1959

(Author's) SUMMARY

Thirty-six volunteer subjects, screened for normal visual acuity, viewed televised displays during a one-hour testing session. There were 252 displays; each consisted of four characters (letters and numbers) of a given size and contrast condition. The study design made it possible to compare visibility across: (1) six viewing distances, (2) three viewing angles, (3) three figure-background contrasts, (4) four character sizes and (5) three time-segments within the testing session. Results indicate that no visual fatigue occurred, that black-on-white and white-on-black contrasts produced about equal visibility, and that characters subtending 10 min of vertical visual angle could be perceived with almost complete accuracy.

(24.128)

A NEW MULTI-LEVEL CODING TECHNIQUE FOR DIGITAL COMMUNICATIONS

J. L. Shagena & J. C. Kvarda,

(Author's) ABSTRACT

In bandwidth limited digital communication systems, it is possible to increase the data rate at the expense of demanding a higher signal-to-noise ratio in the transmission medium. This multi-level coding scheme allows adjustment of this data rate to match the capacity of the channel while maintaining a constant bandwidth; or conversely, for a fixed data rate, it compresses the bandwidth by requiring a higher signal-to-noise ratio.

A data modem equipment using this technique has been developed and is also described in this paper.

B57

(24.8)

A TELEVISION IMAGE SIMULATOR AND ITS PRACTICAL APPLICATIONS

Rostyslav Shavlach, SPIE Journal, October - November 1964

(Author's) ABSTRACT

The television signal resulting from the scanning of an image (such as a photographic transparency) can be processed to achieve interesting and useful effects. Among these effects are variation in resolution and noise, variation of the contrast ratio within any specific range of the gray scale, control of differentiation for bas-relief effects, and production of an equal-brightness contour. Included are the descriptions of the methods of producing the effects and the results attained. Photographs illustrating the various processes are shown to demonstrate the results.

(24.65)

EXPERIMENTAL TRANSMITTING AND RECEIVING EQUIPMENT FOR HIGH-SPEED FACSIMILE TRANSMISSION III. DETAILS OF THE RECEIVER

F. C. W. Slooff, M. Van Tol, and J. M. Unk, Philips Technical Rev. 10, 257-264, 1949, No. 9

(Author's) SUMMARY

In the Philips high-speed facsimile transmission system the signal received, the strength of which varies according to the light and shade of the image being scanned, is employed at the receiver to control the current flowing in a gas-discharge lamp. The varying amount of light from this lamp is projected in the form of a spot onto a film by an optical system rotating in synchronism with the rotor of the transmitter. The film is curved to the cylindrical shape of the rotor and passes the latter continuously, so that the light spot traces on it parallel lines exactly corresponding to the scanning lines at the transmitter. Owing to the very high resolving power of the positive film used, the image can be reproduced in the receiver at 1/6th of the original size, with consequent economy in film. To this end, the diameter of the rotor is only 1/6th the diameter of the rotor at the transmitter, and the recording spot is similarly one-sixth the size of the scanning spot (i.e.  $33\mu$ ). In this case, too, the rotor carries three identical optical systems and the film is curved only through  $120^\circ$ . Tolerances governing the relative position, size and intensity of the spot in the three optical systems are essentially very small and extreme precision in manufacture of the rotor and in assembly is necessary. Whereas in the case of the scanning spot at the transmitter a circular form is the most suitable, a substantially rectangular shape is

(24.65) Continued

better for the recording spot. This is produced by focusing onto the film the image (reduced 4X) of a rectangular diaphragm having all four sides adjustable. The lamp, which is capable of following modulating frequencies up to 100 kc/s and the luminous intensity of which is sufficient to produce a density of 1.5 on the film in 5  $\mu$ sec, is a gas-discharge lamp filled with mercury vapour and argon at low pressure. The discharge is concentrated within a tube 1 mm in width. A steady current flows through the lamp to assist it in following the necessary high modulation and to give the light-versus-current characteristic the desired form for linear reproduction.

(24.9)

#### A TELEVISION IMAGERY SIMULATOR

J. P. Smith and J. F. Baumunk, Journal of the SMPTE, Vol. 70, January 1961

#### (Author's) SUMMARY

For evaluating TV systems and for studying image enhancement techniques, there is a need for simulator equipment with adjustable and measurable parameters. Because results must be duplicated from day to day and from month to month, reliability is of importance in designing the equipment. Also, when evaluating systems of high resolution, the resolution capabilities of the evaluating means must be better than the system under evaluation. The mechanical and electrical design must be flexible so that, when new ideas present themselves, they may be developed and added to the existing equipment. A TV Imagery Simulator which fulfills these requirements has been built by the Astro-Electronic Products Division of RCA and has been in use for over two years.

(24.6)

#### A VIDEO-MODULATION TEST SYSTEM FOR SPACE TELEVISION

G. R. Southworth, Journal of the SMPTE, Vol. 74, April 1965

#### (Author's) SUMMARY

A video-modulation system, applicable to space technology, has been designed for use in the investigation of modulation and transmission of single-frame television images. Design objectives included generation of a high-quality video signal with resolution precisely controllable from approximately 100 X 100

(24.6) Continued

to 1000 X 1000 picture elements. The output signal, limited to the audio-frequency range, permits the operator to generate bandwidths from 100 cycles to 8 kilocycles. An unusual degree of flexibility is provided and the major limitations of conventional slow-scan systems are eliminated.

(24.59)

STORING DATA WITH LIGHT

R. D. Stewart, Electronics, February, 1966

(Author's) SUMMARY

This article, one of a series on optoelectronics, discusses four ways of recording and reading back memory data optically: beam modulation, beam deflection, bistable light emitters and optical delay lines.

(24.120)

SEQUENTIAL OBSERVATIONS BY HUMAN OBSERVERS OF SIGNALS IN NOISE

J. A. Swets & D. M. Green, Information Theory (4th London Symposium)

NO ABSTRACT

(24.129)

PROSPETTIVE DELLE TELECOMUNICAZIONI SPAZIALI

Alberto Tamburrini, Missili E. Spazio, 7, December 1965

(Author's) SUMMARY

Tutte le trasmissioni possono convenientemente essere ridotte al tipo digitale, proprio della trasmissione di dati. Questo sarà facilitato dalla possibilità di sfruttare le attuali tecniche teoriche di codificazione:

(24.129) Continued

molto promettente appare il canale spaziale per quanto riguarda l'uso dei codici ricorrenti (correzione d'errore) che dovrebbero affiancare i codici a blocco (rivelazione d'errore).

Sono accennati i quattro momenti di studio di un canale: esame degli errori, modello matematico, modello fisico, sistemi di codificazione.

(24.142)

**A PSEUDO-RANDOM QUANTIZER FOR TELEVISION SIGNALS**

J. E. Thompson and J. J. Sparkes, Proceedings of the IEEE, Vol. 55, No. 3  
March 1967

(Author's) ABSTRACT

A pseudo-random quantizer has been constructed to operate in a standard 405-line television system using a digital channel of only two bits per sample capacity. The "dirty-window" effect on moving pictures of a synchronized dither signal has been converted to noiselike flicker equivalent to 30 dB S/N ratio.

(24.57)

**HIGH RESOLUTION OPTICAL FILM-SCANNING APPARATUS**

T. Trott, U. S. Patent No. 3,210,468

**NO ABSTRACT**

(24.61)

A SURVEY OF CAMERA TUBES FOR TELEVISION BROADCASTING

Walter E. Turk, Journal of the SMPTE, Vol. 75, Nov. 1966

(Author's) ABSTRACT

The evolution of television camera tubes is traced with major changes and improvements described. The survey covers dynode structure change, image section change, and target changes brought about through use of the electronically conducting glass target.

(24.126)

A SURVEY OF PICTORIAL DATA PROCESSING TECHNIQUES AND EQUIPMENTS

Andries VanDam, AD 626155, August 1965

(Author's) ABSTRACT

In response to the requirement of the Bureau of Supplies and Accounts of the Department of the Navy, and Engineering Data Systems subcommittee 0004, The Moore School of Electrical Engineering of the University of Pennsylvania conducted a survey of pictorial data processing techniques and equipments to serve as a state-of-the-art report.

The information contained in this document was contributed for publication by private industrial organizations and universities. The listed organizations were contacted by means of a form letter and follow-up telephone calls. The material was drawn from special technical responses, brochures, reports, proposals, existing surveys, and published literature. (A partial bibliography is included in the Appendix). Because of time and manpower limitation, the information is published essentially as submitted, and no attempt has been made to verify performance claims or specifications, or to indicate relative merits of competing equipments.

Whereas there exists a number of surveys and compendia, some of them exhaustive, in one or another area of pictorial data processing, there is not, to our knowledge, a single published report which collates and structures existing equipments, and research and development efforts, for the entire range. It is the purpose of this report to approximate such a survey. It is not exhaustive, nor does it cover all of pictorial data processing. We have addressed ourselves primarily to the present and future needs of the Engineering Data generator and user (engineer, scientist, designer, technician, etc.) who wants to communicate in real or near real time with his environment of digital processors.

(24.126) Continued

Sincere appreciation and thanks are extended to the organizations and individuals who contributed their time and effort to this undertaking. The report was prepared by Andries van Dam, with help from David Evans, under the supervision of Drs. Harry J. Gray and Noah S. Prywes.

(24.155)

DATA ACQUISITION AND PROCESSING SYSTEM FOR THE NIMBUS METEOROLOGICAL SATELLITE

Alan Wachtel, 1963 Telemetering Conf. Proc. May 1963

(Author's) SUMMARY

This paper deals with a new data processing system, now under test, conceived for the National Satellite Weather Center of the United States Weather Bureau by ESS GEE, Inc.

The system is designed to accept a wide variety of inputs-including FM, PCM-AM, PDM-AM, serial and parallel digital data-and performs two major functions. The primary function is to format the input data for entry into a computer complex and the secondary task is to provide a means of displaying portions of the data in requisite format.

Flexibility and modularity is emphasized in the system design so that expanded requirements for the processing of additional data can be met readily with only the incorporation of the appropriate signal conditioners. Internal analog data speed buffering and high speed processing are provided so that data received at a wide range of rates can be readily accommodated.

(24.108)

ANALOG DIGITAL CONVERSION OF TV DATA ON MARINER 4

J. Way, Sr. Space/Aeronautics, Vol. 44, August 1965

NO ABSTRACT

(24.96)

ANALOG-FM vs. DIGITAL-PSK TRANSMISSION

James W. Whelan, IEEE Vol. COM-14, No. 3 June 1966

(Author's) ABSTRACT

This paper provides a comparison of the transmission of information in analog form by frequency modulation (FM) and in digital form by phase shift keying (PSK). The two systems are compared on the basis of relative accuracy provided, relative power and bandwidth required, and relative equipment complexity involved, with the emphasis being on spacecraft application.

Although the two systems require about the same transmitter power (within 1 dB) to provide rms output signal-to-noise (S/N) ratios between 20 and 30 dB at threshold, the analog system is generally simpler, whereas the digital system is capable of greater accuracy. However, the digital system is more efficient for extremely high S/N ratios. The transmission bandwidth required by the FM system is less than that for the pulse code modulation (PCM) system for moderate S/N ratios. For S/N ratios above 35 dB, however, the PCM system requires less bandwidth, as well as less power, than the FM system.

Although the analog-FM technique is usually the most straightforward approach, the information may be transmitted in digital form in order to take advantage of one or more of the following factors:

- 1) Transmitter power savings over conventional analog-FM transmission for high S/N ratios
- 2) Ability to regenerate the digital signal
- 3) Solidity with which the information is known when digitized
- 4) Ease of handling YES-NO or ON-OFF signals
- 5) Ease of multiplexing digital signals
- 6) Ability to encrypt the digital signal
- 7) Practicality of processing and sending information at extremely slow rates, as from deep space probes, when in digital form.

(24.82)

DIGITAL TV BANDWIDTH REDUCTION TECHNIQUES AS APPLIED TO SPACECRAFT TELEVISION

James W. Whelan, J. Spacecraft & Rockets Vol. 3, No. 5, May 1966

(Author's) ABSTRACT

Digital data compression techniques suitable for use in transmission of television data from spacecraft are evaluated. Previously proposed compression techniques are summarized briefly, and two new techniques are described. One of these, the nontime-buffered Improved-Gray-Scale (IGS) pulse code modulation (PCM) compression system, was evaluated by scanning slides, digitizing the resultant video signal to 6-bit accuracy, processing the digitized signal, converting it to analog form, and displaying it for photographic reproduction.



This simple system, suitable for spacecraft application, offers a saving of 2-to-1 (three bits per picture element) with very little picture degradation compared to pictures generated by a 6-bit system. Theoretical evaluation of the other, a Coarse-Fine (C-F) PCM system (also nontime-buffered) indicates a possible 2-to-1 saving with essentially no degradation. Systems utilizing time buffering techniques offer bandwidth reductions of as much as 4-to-1, and hybrid systems utilizing both nontime-buffered and time-buffered techniques offer compressions up to 6-to-1 with possibilities of approaching 10-to-1 for average complexity pictures.

(24.119)

#### LENTICULAR STEREOSCOPIIC TELEVISION

Charles White, Symposium on Technology Status & Trends, Huntsville, Ala., 1965

(Author's) ABSTRACT

An old optical technique utilizing cylindrical lenses has been adapted to dynamic displays, with particular reference to television. The techniques also apply to motion picture photography and projection. Two cameras and an electronic switch are required to produce the television picture. The television display itself is a flat-faced cathode ray tube, but the effect of the lenses in front of the display is to cause each eye to view only those portions of the picture that were derived from the appropriate TV camera. Thus the viewer sees what he would see if he were looking at a three dimensional presentation, and his brain therefore visualizes the presentation as being truly three dimensional. The limitation of the original concept, and later concepts which do not have these limitations, are presented.

(24.130)

#### COMPARISON OF CONVENTIONAL AND DIGITAL TIME DISPLAYS

G. Zeff, Ergonomics, Vol. 8, July 1965

(Author's) ABSTRACT

An experiment was devised to compare the speed and accuracy of reading the time from possible forms of conventional rotary clocks and digital clocks for both 12-hour and 24-hour displays.

Twenty subjects were each presented with 96 displays of digital and conventional clocks in a balanced experimental design.

The results showed that the speed of reading (for logging to the nearest minute) is three and a half to four times faster with a digital than with a conventional clock. The errors with a conventional clock are ten times those with a digital clock. No significant difference was found between the 0-12-hour and 13-24 hour displays for either the digital or the conventional clock.

(24.36)

INFORMATION DISPLAYS

EDN, Vol. 11, No. 4, April 1966

(Author's) SUMMARY

Information displays show promise of revising man's entire way of life. At present, displays are revolutionizing how engineers design, how business is conducted and how war is fought. In a few years the display will become a household tool, as common as the telephone is today.

(24.40)

QUESTIONS & ANSWERS CONCERNING MAGNETIC TAPE RECORDING

EDN, March 1966

(Author's) ABSTRACT

Magnetic tape recording has advanced significantly in the past few years. Because of this rapid advance the terminology often is misunderstood. In this article the author answers some of the most frequently asked questions.

(24.37)

RE: MEASURING SIGNAL-TO-NOISE RATIOS

Journal of the SMPTE, Vol. 75, March 1966

NO ABSTRACT

(24.127)

TV DATA COMPACTION STUDY

Radiation Systems Division, AD 637694, Feb. 1966

(Author's) ABSTRACT

This final report, prepared for the U.S. Army Satellite Communications Agency under contract No. DA 28-043-AMC-01677(S), covers the results of the TV Data Compaction Study performed by Radiation Incorporated. The basic objective of the study was to provide data about the characteristics of meteorological weather pictures that would allow efficient application of data compaction processes to the transmission and reproduction of these pictures. The equipment utilized for this study were the government-furnished Automatic Picture Transmission (APT) Ground Station and the Radiation Incorporated Data Management Analyzer (DMA). The APT system provided a means of scanning pictures, generating video signals, transmitting these signals, and then reconstructing a final output picture from this data. The Data Management Analyzer was used to process the data between the transmitter and receiver to simulate an actual data compression transmission system. The flexibility of the DMA enabled the selection of a number of different processing modes and provided all required data to quickly evaluate the effects of these different processes. The goal of the study was to obtain a minimum reduction ratio of 5 to 1 with acceptable picture quality. This goal was accomplished.

(24.35)

DECISION CELLS SIMPLIFY WEATHER-SATELLITE DATA

Author Unknown, Machine Design, Jan 20, 1966

NO ABSTRACT

(24.133)

MANNED SPACECRAFT ADVANCED DIGITAL TELEVISION COMPRESSION STUDY

N66-37290 (Vol. 1 Text) April 1965

(Author's) ABSTRACT

The information presented in this report represents the results of a seven month investigation (combining theoretical and experimental approaches) into advanced digital television techniques having potential application to future manned spacecraft missions. The information is presented in two volumes. Text Volume I incorporates in Sections 2 through 5 the summary results of the various study tasks. Program conclusions and recommendations are given in Sections 6 and 7, respectively, and the detailed results of the study tasks appear in Appendices A through F. Volume II, the photographic volume, includes the pictorial results obtained in several of the supporting experimental areas.

(24.133)

MANNED SPACECRAFT ADVANCED DIGITAL TELEVISION COMPRESSION STUDY

N66-37291 (Vol. 2 Photographs) April 1965

(Author's) ABSTRACT

(See above)

(24.71)

PRODUCT PROFILE XEROX "LDX"

S.P.I.E. Journal. Vol. 2 April, May 1964

NO ABSTRACT

(24.38)

PROJECT TELSTAR

A.C. Dickieson, Bell Lab Record, April 1963

(Author's) SUMMARY

This article "sets the stage" for the discussion of the Telstar experiment, which culminated in the transmission of television across the Atlantic on July 10, 1962.

(24.55)

WHEN TELETYPE OR VOICE WON'T WORK ....SEND IT BY MICROWAVE

Oil & Gas Journal, V54, No. 4, Nov. 21, 1955

NO ABSTRACT

(24.81)

DOT SYSTEMS OF COLOR

Electronics, Jan 1950

(Author's) SUMMARY

Sampling and multiplexing techniques permit transmission of color television pictures in the presently assigned channel bandwidth. Several systems of dot sequential color that may be compatible with black and white are described.

(24.72)

PICTURE PROCESSING AT JPL (unofficial title)

JPL Technical Report No. 32-1028

(Author's) ABSTRACT

The interpretation of medical and biological pictures, such as x-ray photographs, can frequently be made easier if selected portions of the image are first enhanced by means of a digital computer. Two particular enhancement methods are described in this Report. The first method uses image subtraction to achieve enhancement by removing unimportant information from the picture. The second method uses two-dimensional filtering to achieve enhancement by emphasizing selected portions of the picture frequency spectrum. This filtering method is particularly useful for bringing out fine detail that is totally invisible on the unprocessed picture. Examples of enhanced medical x-rays, photomicrographs, and infrared photographs are shown.